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DESIGN SPECIFICATION FOR

METAL PLATE CONNECTED WOOD TRUSSES

TPI-85

RECOMMENDED DESIGN PRACTICE BY

TRUSS PLATE INSTITUTE

583 D'Onofrio Drive, Suite 200
Madison, WI 53719
(608) 833-5900

PLATE MANUFACTURER MEMBERS OF THE TRUSS PLATE INSTITUTE, INC.

ALPINE ENGINEERED PRODUCTS, INC.
Post Office Box 2225
Pompano Beach, Florida 33061

CLARY CORPORATION
1801 S. Great SW Parkway
Grand Prairie, Texas 75051

GANG-NAIL SYSTEMS, INC.
7525 N.W. 37th Avenue
Miami, Florida 33147

HYDRO-AIR ENGINEERING, INC.
Post Office Box 7359
St. Louis, Missouri 63177

INTER-LOCK STEEL CO., INC.
3679 East State Street
Sharon, Pennsylvania 16146

LINK-WOOD CONSTRUCTION SYSTEMS
Post Office Box 270
Mansfield, Texas 76063

LUMBERMATE COMPANY
10443 Baur Boulevard
St. Louis, Missouri 63132

ROBBINS MANUFACTURING COMPANY
P.O. Box 17937
Tampa, Florida 33682

THE PANEL-CLIP COMPANY
Post Office Box 423
Farmington, Michigan 48024

TEE-LOK CORPORATION
Post Office Box 585
Edenton, North Carolina 27932

TRUSS CONNECTORS OF AMERICA
2675 S.W. 69th Court
Miami, Florida 33155

TRUSWAL SYSTEMS CORPORATION
8925 Sterling Street, Suite 150
Irving, Texas 75063

25 ANNIVERSARY

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TRUSS PLATE INSTITUTE, INC.

An association of manufacturers actively engaged in the production of metal connector plates for the wood truss industry, manufacture of metal plate connected wood trusses, and individuals or firms engaged in related activities, the Truss Plate Institute was organized in 1961 for the purpose of maintaining the industry on a sound engineering basis. To accomplish its purpose, the institute establishes methods of design and construction for wood trusses using metal connector plates, supports and disseminates test and research data, assists in the development of proper building code regulations, recommends quality control standards, and distributes information on the use of wood trusses in the interest of public safety.

NOTICE

These recommendations for the design of metal plate connected wood trusses originate from the collective experience of leading technical personnel in the metal plate connected wood truss industry, but must, due to the nature of the responsibilities involved, be presented only as a guide for the use of a qualified engineer or designer. By publishing this booklet, the Truss Plate Institute, Inc. and its member companies do not warrant the recommendations and information contained herein as proper under all conditions and expressly disclaim any responsibility for damages arising from the use, application, or reliance on the recommendations and information contained herein.

FOREWORD

The purpose of this Design Specification is to present criteria and procedures for design by those familiar with engineering principles. It is not intended that information found in engineering textbooks, which include derivation of formulas, be included nor that all truss configurations and details be included.

Recommended design criteria were first formulated prior to the formation of the Truss Plate Institute, based on work of an interim committee in 1959. The 1960 version of the design criteria was published with the designation "TPI-60." Since that time, the Technical Advisory Committee, composed primarily of registered professional engineers, has continued to study and evaluate new data and developments in the metal plate connected wood truss industry; thus TPI-62, TPI-65, TPI-66, TPI-68, TPI-70, TPI-74 and TPI-78 were published. Appropriate revisions are made to provide for the use of new information when it is considered technically sound.

TECHNICAL ADVISORY COMMITTEE
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PART I GENERAL

1.1 Introduction

1.1.1 Metal plate connected wood trusses are planar structural components. Structural performance depends on the trusses being installed vertically, in-plane, and at specific spacing, and being properly fabricated (See Reference 11, Appendix G) and braced (See Reference 12, Appendix G). This Specification describes the materials used in a truss, both lumber and steel, and design procedures for truss members and joints. Methods for evaluating the plates and procedures for load testing the trusses are contained in the appendices.

1.1.2 Buckling and moment length factors have been developed for the truss configurations shown in Figure 1. These factors are the result of extensive technical studies and are recommended for the design of those trusses. Other truss configurations are being studied and will be included when the studies are completed.

1.1.3 For the design of parallel chord 4×2 trusses, the design criteria published by the Truss Plate Institute as PCT-80 are to be used.

1.1.4 The Purdue Plane Structures Analyzer II (PPSA II) or other accepted engineering practice may be used to design any truss configuration, including those shown in Figure 1. Special cases, such as trusses having concentrated loads and/or bearings not at panel points, attic frames, or trusses with redundant supports, require an analysis by PPSA II or other accepted engineering practice. (See Reference 20, Appendix G.)

1.1.5 This Specification does not cover design for the complete structural system of a building. Provisions shall be made for bearings, cross and lateral bracing, bracing to transfer truss member buckling forces to the structure, and bracing to resist wind, seismic or other horizontal loadings by those responsible for the overall building design.

1.1.6 Field erection of the trusses (including considerations such as proper handling, safety precautions, temporary and permanent bracing, and other safeguards or procedures consistent with good workmanship and good building erection practices) is not the responsibility of the truss fabricator, truss designer, or the plate manufacturer, and is not included in this Specification. However, it should be noted that during erection each truss should be adequately braced. The general contractor and/or the erection contractor shall insure that handling and erection procedures do not reduce the load carrying capacity of the truss.

1.2 Engineering Data for Wood Truss Design

1.2.1 Designs shall contain the following information:

(a) Slope or depth, span and spacing of the truss.

(b) Bearing width.

(c) Design loading to include, as applicable:

1. Top chord live load
2. Top chord dead load
3. Bottom chord live load
4. Bottom chord dead load
5. Concentrated loads and their points of application.

(d) Adjustment to lumber and plate design values for conditions of use.

(e) Each reaction force.

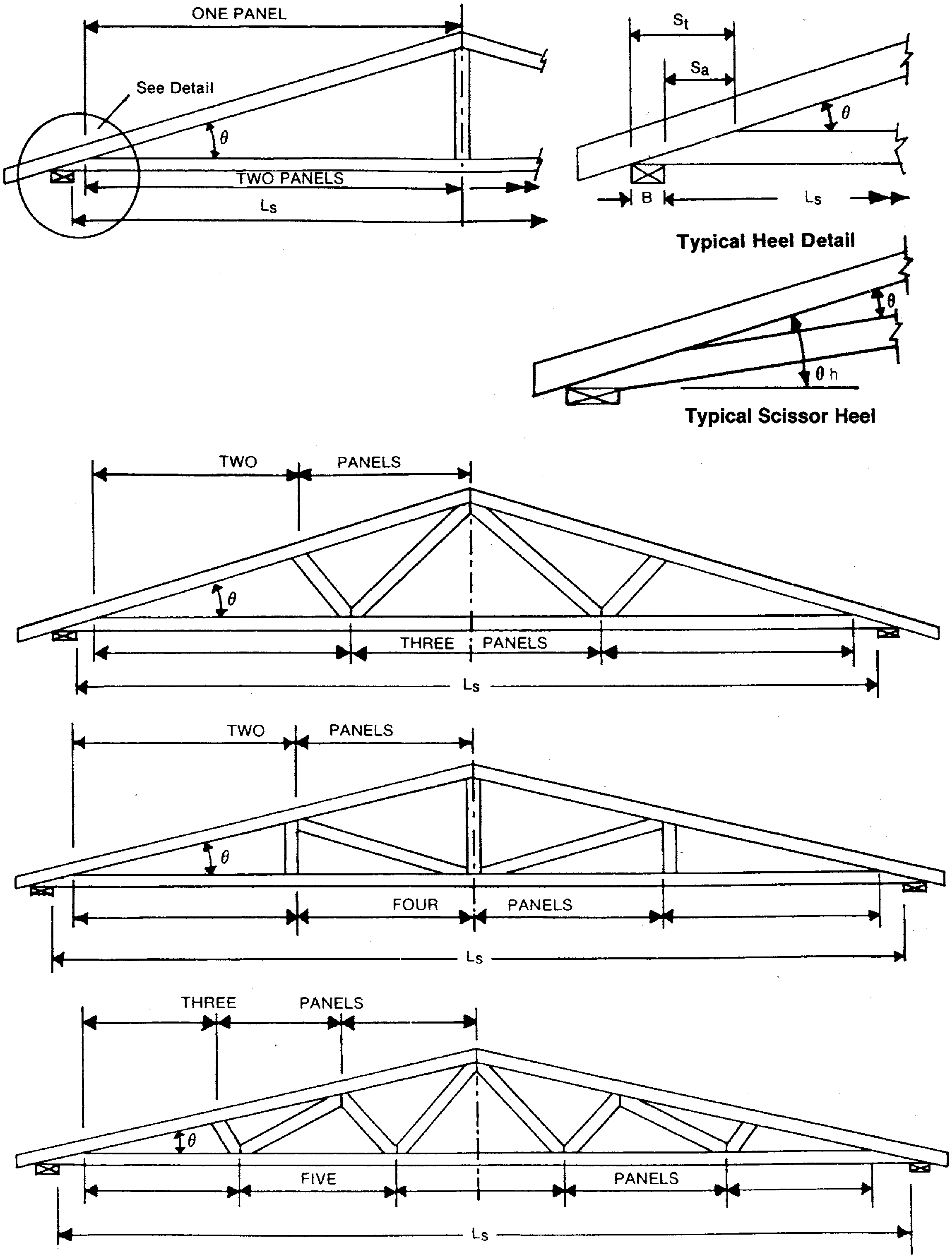
(f) Plate type, thickness or gage, size; basic plate design value (specifying gross or net value, see Appendix C); and the dimensioned location of each plate except where symmetrically located relative to the joint interface.

(g) Lumber size, species, and grade for each member.

1.2.2 Design calculations for axial forces and moments shall be available from the designer.

1.3 Handling

Care should be exercised at all times to avoid damage through careless handling during storage, delivery, unloading and erection of trusses.



Typical Heel Detail

Typical Scissor Heel

Figure 1 - Standard Truss Configurations

1.4 Abbreviations

AISI	American Iron and Steel Institute 1000 16th Street, N.W. Washington, D.C. 20036
AITC	American Institute of Timber Construction 333 West Hampden Avenue Englewood, Colorado 80110
ALSC	American Lumber Standards Committee P.O. Box 210 Germantown, Maryland 20874
ANSI	American National Standards Insitute 1430 Broadway New York, New York 10018
ASTM	American Society for Testing and Materials 1916 Race Street Philadelphia, Pennsylvania 19103
FPL	Forest Products Laboratory USDA Forest Service Post Office Box 5130 Madison, Wisonsin 53705
NDS	*National Design Specification for Wood Construction,* 1982 Edition, Recommended Practice for Structural Design by NFPA.
NFPA	National Forest Products Association 1619 Massachusetts Avenue, N.W. Washington, D.C. 20036
PPSA	Purdue Plane Structures Analyzer II, General Technical Report FPL-40 published by the Forest Products Laboratory.

1.5 Notation and Symbols

A	Cross-sectional area
B	Width of bearing
B_R	Minimum required bearing
C_T	Buckling stiffness factor
D	Factor used to calculate chord stiffness for a cantilever analysis
E	Modulus of elasticity
F_b	Design value for extreme fiber in bending
F'_b	Design value for extreme fiber in bending, adjusted by slenderness factor
F_c	Design value for compression parallel to grain
F'_c	Design value for compression parallel to grain, adjusted for L'/d ratio
F_s	Basic allowable shear stress in steel
F_{st}	Basic allowable tensile stress in steel
F_t	Design value for tension parallel to grain in lumber
F_u	Ultimate tensile strength of steel
F_y	Steel yield point
H_E	Factor used in cantilever analysis
I	Moment of inertia
J	Unitless factor used in interaction equation for combined bending and axial compression
K	Largest slenderness ratio L'/d at which intermediate column formula applies for determining design value in compression parallel to grain
L	Nominal panel length of chords used in computing bending moment and buckling length
L'	Effective buckling length
L_1, L_2	Panel lengths of bottom chord members
L_a	Longer of panel length(s) adjacent to L_i
L_B	Length (inches) of bottom chord panel one from intersection of chord centerlines to first panel point
L_{1B}	Length (inches) of bottom chord panel one from crotch to first panel point
L_{2B}	Length (inches) of bottom chord panel two
L_C	Length (inches) of cantilever from intersection of chord centerlines to centerline of bearing
L_D	Length (inches) of reinforced heel from intersection of chord centerlines to inside end of wedge
L_H	Length (inches) of heel from intersection of chord centerlines to crotch
L_i	Length of panel under investigation
L_K	Length (inches) of cantilever from end of bottom chord to outside end of bearing
L_p	Distance between lateral supports of weak axis

L_R	Length (inches) of reinforcement (wedge)
L_s	Clear span length measured from face to face of supports
L_T	Horizontal length (inches) of top chord panel from intersection of chord centerlines to first panel point
L_{1T}	Horizontal length (inches) of top chord panel one from crotch to first panel point
L_{2T}	Horizontal length (inches) of top chord panel two
L_w	Actual centerline length of web member
M	Bending moment
M_B	Bottom chord moment (in-lbs) used in cantilever analysis
M_T	Top chord moment (in-lbs) used in cantilever analysis
P	Axial load
P_B	Bottom chord axial force (lbs) used in cantilever analysis
P_T	Top chord axial force (lbs) used in cantilever analysis
Q	Buckling and moment length factor
R_B	Component of gross reaction (lbs) applied as a vertical concentrated load to bottom chord in cantilever analysis
R_G	Gross reaction (lbs)
R_T	Component of gross reaction (lbs) applied as a vertical concentrated load to top chord in cantilever analysis
S	Section modulus
S_a	Adjacent scarf
S_t	Total scarf
V_A	Factor used in cantilever analysis
V_E	Factor used in cantilever analysis
b	Thickness of member
c	Scarf averaging factor
d	Width of member or critical dimension of rectangular member in buckling
h	Width of member
w	Uniformly distributed load
w'_B	Uniform distributed load on bottom chord
w'_T	Uniform distributed load on top chord
α,β	Constants used to derive buckling and moment lengths
θ	Angle between top and bottom chord (degrees)

PART II MATERIALS

2.1 Lumber

2.1.1 Design values for lumber shall be in accordance with the published values of lumber rules writing agencies approved by the Board of Review of the American Lumber Standards Committee. Lumber shall be identified by the grade mark of a lumber inspection bureau or agency approved by the Board of Review of the American Lumber Standards Committee.

2.1.2 Lumber design values, except E, may be adjusted for duration of load conditions by multiplying by the following factors:

Permanent loads	0.90
Normal loads 10 Years duration	1.00
Snow loads 2 Months duration	1.15
Construction loads 7 Days duration	1.25
Wind or Earthquake 1 Day duration	1.33

For other load duration factors see Appendix I.

2.1.3 Design values may be adjusted for combinations of loads of different durations in accordance with the provisions of Paragraph B.2, Appendix B, NDS.

2.1.4 Where three or more trusses are positioned side by side, are spaced no more than 24 inches on center and are joined by roof sheathing, flooring, or other load distributing elements attached directly to the chords, F_b may be increased 15 percent, or if repetitive member design values are listed in the recognized lumber grading rules, they may apply.

2.1.5 All fire retardant treated lumber used in trusses shall be redried after treatment in accordance with American Wood preservers Association Standard C20. (See Reference 21, Appendix G.)

2.2 Steel and Plates

2.2.1 Each configuration and thickness classification of plate shall be evaluated in full size truss tests for truss and joint performance, for ultimate values to determine allowable design values for plate tension and plate shear, and for yield and ultimate values to determine allowable design values for lateral resistance between wood and plate, "in accordance with TPI test methods."

2.2.2 Plates shall be of galvanized sheet steel conforming to the requirements of Section 2.2.2.1 or Section 2.2.2.2, aluminum-zinc alloy coated sheet steel conforming to the requirements of Section 2.2.2.3, or shall be stainless steel conforming to the requirements of Section 2.2.2.4.

2.2.2.1 Structural (physical) quality galvanized sheet steel shall meet or exceed ASTM A446, Standard Specification for Sheet Steel, Zinc Coated (Galvanized) by the Hot-Dip Process, Structural (physical) quality, Grade A, and galvanized coating shall meet or exceed ASTM, A525, Standard Specification for Steel Sheet, Zinc Coated (Galvanized) by the Hot-Dip Process, General Requirements, Coating Designation G60. Minimum thickness of steel shall not be less than 0.036 inches (coated thickness), minus 0.000 inch tolerance.

2.2.2.2 Structural (physical, quality galvanized sheet steel shall meet or exceed ASTM A591, Standard Specifications for Steel Sheet, Cold Rolled, Electrolytic Zinc Coated, Coating Class C. Structural properties shall meet or exceed those specified in Section 2.2.2.1. Minimum thickness of steel shall not be less than 0.047 inches (coated thickness), minus 0.000 inch tolerance.

2.2.2.3 Structural (physical) quality, aluminum-zinc alloy coated sheet steel shall meet or exceed ASTM A792, Standard Specification for General Requirements for Steel Sheet, Aluminum-Zinc Alloy Coated by the Hot-Dip Process, AZ-50 coating weight. Structural properties and minimum thickness of steel shall meet or exceed those specified in Section 2.2.2.1.

2.2.2.4 Stainless sheet steel shall meet or exceed ASTM A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip and ASTM A480 Standard Specification for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip. Structural properties shall meet or exceed those specified in 2.2.2.1. Minimum thickness of steel shall not be less than 0.035 inches, minus 0.000 inch tolerance.

2.2.3 Minimum thickness in inches (coated thickness, if galvanized or aluminum-zinc alloy coated), minus 0.000 inch tolerance, shall be specified for each type of plate. The following gage designations may be used in lieu of specifying minimum thickness provided the plate thickness equals or exceeds the thickness listed, minus 0.000 inch tolerance.

20 gage 0.036 inch minimum thickness
18 gage 0.047 inch minimum thickness
16 gage 0.058 inch minimum thickness
14 gage 0.071 inch minimum thickness

2.2.4 Minimum steel mechanical requirements shall include:

Yield Point	$F_y = 33{,}000$ psi
Ultimate Strength	$F_u = 45{,}000$ psi

2.2.5 Working stresses in steel are to be applied to effectiveness ratios for plates as determined by test and shall be:

Basic Allowable Tensile Stress
$F_{st} = 0.60\ F_y$
Basic Allowable Shear Stress
$F_s = 0.40\ F_y$

2.2.6 The design thickness of plates for use with F_{st} and F_s to determine steel tension and shear design values shall be the minimum steel thickness, specified, less any coating thickness, divided by 0.95. This resulting dimension shall be considered the mean thickness of the base metal. For galvanized steel coating thickness deductions shall be:

G60 Designation, 0.001″
Electrolytic, 0.001″

For aluminum-zinc alloy coated steel, coating thickness deduction shall be 0.002″.

These deductions are the total for both sides.

2.2.7 The plate manufacturer shall maintain records that include the following information for each master coil of steel used in truss plate production:

Name of steel producer
Material description and specification
Heat Number
Yield point
Tensile strength
Elongation
Chemical analysis

Records shall be kept for a minimum period of three years following plate production.

2.2.8 On plates without integral teeth, there shall be provided some means, such as holes, dimples, bosses or marked pattern, to indicate the location of any separately applied nails for fasteners. Blank plates without any type of indicated minimum spacing for the nails or fasteners shall not be acceptable.

2.2.9 Plates shall be manufactured with all holes, plugs, teeth or prongs properly spaced and properly formed.

2.2.10 All plates 3 inches in width or wider and 25 per cent of plates less than 3 inches in width shall be individually marked with the name or symbol of the manufacturer.

2.2.11 Galvanized coating can be applied to the sheet steel prior to the plate fabrication or stamping. Aluminum-zinc alloy coating must be applied to the sheet steel prior to the plate fabrication or stamping. It is not necessary to recoat the plates after the stamping operation.

2.2.12 For plates used with chemically treated lumber, such as but not limited to fire retardant treatment, or for plates used in unusual environmental conditions or exposed to the weather, additional corrosion resistant protection for the plates may be required.

PART III MEMBER DESIGN PROCEDURES

3.1 Design Model

3.1.1 The axial forces, bending moments, and effective buckling lengths shall be based on a mathematical model of the truss that closely approximates the geometry of the truss members. The model shall be based upon the member properties published by the National Design Specification for Wood Construction (Reference 1, Appendix G).

3.1.2 The model shall consider the effect of continuity of the truss over interior supports where appropriate.

3.1.3 The model should consider the chords as continuous members pinned only at member ends where the pitch of the chord abruptly changes.

3.1.4 The model shall consider all web members to be pinned at member ends.

3.1.5 The truss may be modeled assuming all members to be pin-connected for determination of axial forces.

3.1.6 The heel joint may be modeled as pinned or may be modeled as an assembly of chord members and fictitious members.

3.2 Moment and Buckling Analysis

3.2.1 The design moment used to size chord members shall be determined by an exact analysis method or shall be determined by the simplified method described in PART III.

3.2.2 An exact analysis method is one that determines the axial forces and bending moments of the truss-frame model and satisfies all equations of equilibrium and compatibility. Matrix methods of structural analysis such as the Purdue Plane Structures Analyzer (PPSA) are examples of exact methods.

3.2.3 The effective buckling lengths (L′) for chord members shall be determined by a thorough structural analysis method such as the Purdue Plane Structures Analyzer II (PPSA II) or by the simplified method described in PART III.

3.2.4 The effective buckling length (L′) for buckling within the plane of the truss need only be determined when checking combined stress between panel points. Hence L′/d is considered equal to 11 when checking combined stress at a panel point with respect to the strong axis. See also Section 3.4.10 for buckling perpendicular to the plane of the truss. See Fig.3.

3.3 Empirical Analysis

3.3.1 This method has been developed based upon many years of experience in wood truss design and extensive investigation using the PPSA on standard truss configurations. This simplified method is generally considered to be conservative, but it is impossible to insure that this method is suitable for all of the possible loadings, spans, and geometric conditions. This method is intended for use by a professional engineer experienced in the design of wood trusses. The engineer must use judgment with respect to the suitability of this method for any given application.

3.3.2 Critical top chord bending moments shall be checked at panel points (panel point moment) and between panel points (mid-panel moment). These two moments shall be used when determining the critical combined stress of the top chord in 3.4.8.

3.3.3 For uniformly distributed loads, top chord moments are determined on the basis that the chord has a continuous slope and is continuous over web supports. Panel point moments and mid-panel moments shall be:

$$M = \frac{w\,(Q\,L)^2}{8}$$

3.3.4 Q and L for top chords shall be determined by:

a) Table 3.1 for triangular and scissor truss types,
b) Table 3.2 for all monopitch and monoscissor truss types, and
c) Table 3.3 for all continuous chord segments not in contact with heel joints,

but Q shall not be less than 0.74.

3.3.5 Table 3.1 should be used for all top chord segments that are in contact with heel joints and are not monopitch or monoscissor truss types, but Q shall not be less than 0.74.

3.3.6 The effective buckling length (L′) shall be:

$$L' = Q\,L\,\sec\theta_h$$

where θ_h is the angle of the chord with respect to the horizontal.

TABLE 3.1 Top Chord Factors for Triangular & Scissor Trusses

PANEL POINT MOMENT		MID-PANEL MOMENT	
Q	L	Q	L
One Panel Not Applicable	**One Panel** Not Applicable	**One Panel** 0.90	**One Panel**[3] $L_i + S_a$
Two Panels 0.90	**Two or Three Panels**[1] Largest of: $0.9\ L_i$, or $\frac{(L_i + L_a)}{2}$, or $0.9\ L_a$	**Two Panels**[2] $0.58\ (\cot \theta)^{0.23}$	**Two or Three Panels**[3,4] Largest of: $0.9\ (L_i + cS_a)$, or $\frac{(L_i + L_a)}{2} + cS_a$, or $0.9\ (L_a + cS_a)$
Three Panels 0.85		**Three Panels**[2] $0.53\ (\cot \theta)^{0.36}$	

[1] If S_t exceeds 24 inches, add excess to end (heel) panel L_i or L_a (see Figure 2).
[2] $Q = \alpha\ (\cot \theta)\beta$ but shall not be less than 0.74; α and β are constants derived from PPSA analysis.
[3] $S_a = S_t - B$ but not less than zero. cS_a shall be added only to the length of the end (heel) panel.
[4] $c = 0.5$ for two panels; $c = 0.33$ for three panels; if neither L_i nor L_a are end (heel) panel lengths, then $cS_a = 0$.

3.3.7 For a uniformly distributed load the critical bottom chord moment shall be:

$$M = \frac{w\ (Q\ L)^2}{8}$$

where L and Q are show in Table 3.4.

3.3.8 The number of panels used to determine Q and L in Table 3.1 through Table 3.4 shall be the number of panels in the continuous chord segment.

3.3.9 L_i, L_a, S_t, and S_a used in Table 3.1 through Table 3.4 shall be determined per Figure 2. For continuous chord segments that are not in contact with a heel joint S_t and S_a shall be equal to Zero.

3.4 Member Design

3.4.1 Design of members shall be based on dressed sizes as set forth by the American Softwood Lumber Standard (see Reference 18, Appendix G). If other sizes are used, the net dressed size shall be stated in the design and used in the design calculations.

3.4.2 Members subject to axial tension only shall be so proportioned that:

TABLE 3.2 Top Chord Factors for Monopitch & Monoscissor Trusses

PANEL POINT MOMENT		MID-PANEL MOMENT	
Q	L	Q	L
One Panel N/A	**One Panel** N/A	**One Panel** 1.00	**One Panel**[3] $L_i + S_a$
Two Panels 0.90	**Two or More Panels** Largest of: $0.9\ L_i$, or $\frac{(L_i + L_a)}{2}$, or $0.9\ L_a$	**Two Panels**[2] 0.90	**Two or More Panels**[3,4] Largest of: $0.9\ (L_i + cS_a)$, or $\frac{(L_i + L_a}{2} + cS_a$, or $0.9\ (L_a + cS_a)$
3 or 4 Panels 0.90		**3 or 4 Panels**[2] $0.58\ (\cot \theta)^{0.23}$	
5 or 6 Panels 0.85		**5 or 6 Panels**[2] $0.53\ (\cot \theta)^{0.36}$	

[1] If S_t exceeds 24 inches, add excess to end (heel) panel L_i or L_a (see Figure 2).
[2] $Q = \alpha\ (\cot \theta)\beta$ but shall not be less than 0.74; α and β are constants derived from PPSA analysis.
[3] $S_a = S_t - B$ but not less than zero. cS_a shall be added only to the length of the end (heel) panel.
[4] $c = 0.5$ for two panels; $c = 0.33$ for three panels; if neither L_i nor L_a are end (heel) panel lengths, then $cS_a = 0$.

TABLE 3.3 Top Chord Factors for Chord Segments Without Heel Joints, for Top Chords with slopes of less than 1½/12

PANEL POINT MOMENT		MID-PANEL MOMENT	
Q	**L**	**Q**	**L**
Not Applicable*		**One Panel** 0.95	**One Panel** L_i
		Two Panels 0.90	**Two or More Panels** L is largest of: $(L_i + L_a)/2$, or 0.9 L_a, or 0.9 L_i
		Three or More Panels 0.85	

*As these factors are derived from TPI-74, only mid-panel members are considered critical

$$\frac{P}{A} \leqslant F_t$$

3.4.3 Members subject to axial compression only shall be so proportioned that:

$$\frac{P}{A} \leqslant F'_c$$

where F'_c is determined per Table 3.5.

3.4.4 Members subject to bending only shall be so proportioned that:

$$\frac{M}{S} \leqslant F'_b$$

3.4.5 F'_b shall be determined per Table 3.6 where C_s is taken as:

$$C_s = \sqrt{\frac{1.92\ L_u h}{b^2}}$$

L_u shall be the spacing between purlins or bracing at the top (compressive) edge of the chord member. For bottom chord members under downward load with no lateral support, L_u shall be equal to the length of the bottom chord.

3.4.6 When the top (compressive) edge of a chord member is braced throughout its length by continuous sheathing, C_s shall be taken as zero.

3.4.7 Members subject to both bending and axial tension shall be so proportioned that:

$$\frac{P/A}{F_t} + \frac{M/S}{F_b} \leqslant 1.00$$

and

$$M/S - P/A \leqslant F'_b$$

3.4.8 Members subject to both bending and axial compression shall be so proportioned that:

$$\frac{P/A}{F'_c} + \frac{M/S}{F'_b - J\ (P/A)} \leqslant 1.00$$

where J is determined by:

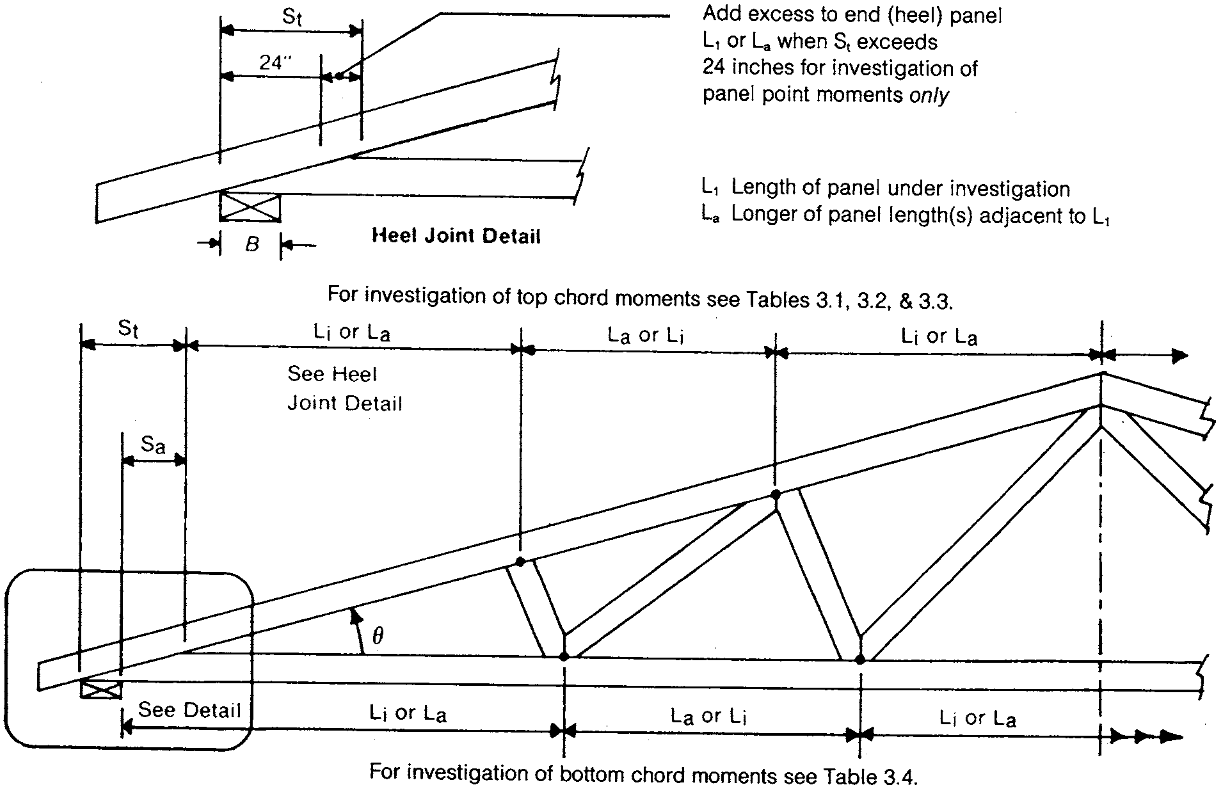
$$J = \frac{L'/d - 11}{K - 11}$$

except that J shall not be less than zero nor greater than one.

3.4.9 Chord members that are braced throughout their length by continuous sheath-

TABLE 3.4 Bottom Chord Factors

Q	L
One Panel 1.0	**One Panel** L_i
Two or More Panels 1.0	**Two or More Panels** L is largest of: 0.9 L_i, or $\frac{(L_i + L_a)}{2}$, or 0.9 L_a


St
24"
B
Heel Joint Detail
For investigation of top chord moments see Tables 3.1, 3.2, & 3.3.
St
Li or La
La or Li
Li or La
See Heel Joint Detail
Sa
θ
See Detail
Li or La
La or Li
Li or La
For investigation of bottom chord moments see Table 3.4.

Add excess to end (heel) panel L_1 or L_a when S_t exceeds 24 inches for investigation of panel point moments *only*

L_1 Length of panel under investigation
L_a Longer of panel length(s) adjacent to L_1

Figure 2 - Top and Bottom Chord Panel Lengths

ing need only be checked per Section 3.4.8 for buckling within the plane of the truss. Hence F'_c and J shall be based upon L′/d where d is equal to h in Figure 3.

3.4.10 Chord members that are not continuously braced throughout their length shall be checked per Section 3.4.8 for both buckling within the plane of the truss and buckling within a plane perpendicular to the plane of the truss. For buckling in the plane perpendicular to the truss, J shall be set equal to zero and F'_c shall be determined based upon L′/d where:

a) L′ is equal to L_p, and
b) d is equal to b

as shown in Figure 3.

3.4.11 The buckling stiffness factor (C_t) used

TABLE 3.5 Formulas for Determine F'_c and K

L′/d Ratio[1]	**Visually Graded Lumber**	**Machine Stress Rated Lumber**[2]
$L'/d \leq 11$	$F'_c = F_c$	$F'_c = F_c$
$11 < L'/d < K$	$F'_c = F_c\left[1 - \frac{1}{3}\left(\frac{L'/d}{K}\right)^4\right]$ where $K = 0.671\sqrt{\frac{E\,C_T}{F_c}}$	$F'_c = F_c\left[1 - \frac{1}{3}\left(\frac{L'/d}{K}\right)^4\right]$ where $K = 0.792\sqrt{\frac{E\,C_T}{F_c}}$
$L'/d \geq K$	$F'_c = \frac{0.30\,E\,C_T}{(L'/d)^2}$	$F'_c = \frac{0.481\,E\,C_T}{(L'/d)^2}$

[1] See Figure 3 for L.
[2] See Paragraph G.9, Appendix G, National Design Specification for Wood Construction, 1982 Edition.

TABLE 3.6 Formulas for Determining F'_b

C_s Value	Visually Graded Lumber	Machine Stress Rated Lumber
$C_s \leqslant 10$	$F'_b = F_b$	$F'_b = F_b$
$10 < C_s \leqslant C_k$	$F'_b = F_b\left[1 - \frac{1}{3}\left(\frac{C_s}{C_k}\right)^4\right]$ where $C_k = 0.811\sqrt{\frac{E}{F_b}}$	$F'_b = F_b\left[1 - \frac{1}{3}\left(\frac{C_s}{C_k}\right)^4\right]$ where $C_k = 0.956\sqrt{\frac{E}{F_b}}$
$C_s > C_k$	$F'_b = \frac{0.438\ E}{(C_s)^2}$	$F'_b = \frac{0.609\ E}{(C_s)^2}$

in Table 3.5 may be determined by 3.4.12 if the following conditions are met:

a) the member size is 2×4 or smaller,
b) continuous 3/8 inch or thicker plywood sheathing is attached to the narrow face of the chord in accordance with good nailing practice,
c) the member is subjected to combined bending and axial compression, and
d) the trusses are used under dry service conditions.

If these conditions are not met, C_t shall be taken as equal to one.

3.4.12 If the conditions stated in 3.4.11 are met, the buckling stiffness factor (C_t) may be determined as;

$$C_t = 1 + \frac{2300\ L'}{k\ E}$$

for wood seasoned to a moisture content of 19 percent or less at the time the plywood is applied to the chord, or as:

Member	Effective Dimension (d)	Effective Buckling Length (L')
Top Chord	**h**	**See 3.2.3**
	b	L_p
Bottom Chord	**h**	L_1, L_2
	b	L_p
Web	**h**	$0.8\ L_w$
	b	L_p or $0.8\ L_w$

Where sheathing or ceiling is nailed to a compression chord (either top or bottom), lateral support of the supported axis may be assumed to be continuous and L'/d = Lp/b may be neglected.

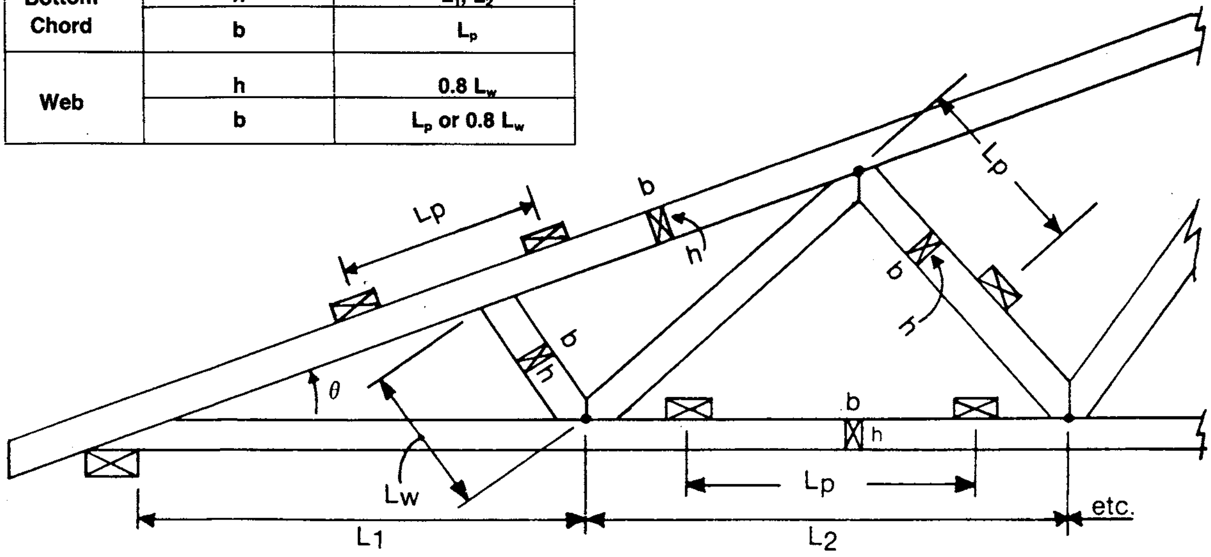


Figure 3 - Effective Buckling Lengths

$$C_t = 1 + \frac{1200\ L'}{k\ E}$$

for wood that is unseasoned or partially seasoned at the time of plywood attachment; where:

L' = effective buckling length in inches, but not greater than 96 inches, and
k = 0.819 for machine stress rated lumber or
k = 0.589 for visually graded lumber.

3.4.13 The maximum L'/d for compression members shall not exceed 50, and the maximum L'/d for tension members, including tension members subject to reversal of stress, shall not exceed 80. For chords and webs the effective buckling length shall be as shown in Figure 3.

3.4.14 Metal web members shall conform with the provisions of the AISI Specification for the Design of Cold-Formed Steel Structural Members.

3.4.15 Sufficient bearing at each reaction shall be specified for the truss member.

PART IV JOINT DESIGN

4.1 Plates of a size determined by the basic design value (lateral resistance) shall be installed on both faces of each joint and there shall be wood to wood bearing for each member meeting at a joint to resist applicable forces in accordance with the following:

(a) To allow for moment effects at the heel joint, the heel plate shall be designed to have sufficient capability to withstand the direct axial force of the top and bottom chords using basic plate design values (lateral resistance) reduced as follows:

Reduction factor =
$0.85 - 0.05\,(12 \tan\theta - 2.0)$
but not less than 0.65 nor greater than 0.85

The reduction factor takes into consideration the end and edge distance requirements for the heel plate; therefore, the end and edge distance requirements of 4.1 (b) are not applicable to heel plate design.

(b) For plates rated by the Net Plate Area method, exclude a ½ inch end distance measured parallel to the grain and ¼ inch edge distance measured perpendicular to the grain when determining the plate coverage for each member of a joint (see Figure 4). When the Gross Plate Area method is used, the end and edge distance exclusions do not apply.

(c) The peak plate shall have sufficient capability to resist 50 per cent of the design compression force in the top chord member.

(d) Plates at all joints shall have sufficient teeth, nails or plug groups to develop a minimum of 375 pounds axial force in all members at the plate basic design value (lateral resistance).

4.2 Plate basic design values (lateral resistance) established in accordance with TPI plate evaluation criteria shall be reduced 20 per cent when the plates are to be installed in lumber having a moisture content greater than 19 per cent at the time of fabrication.

4.3 The basic design values of plates (lateral resistance) may be adjusted for various durations of load by multiplying by the factors listed in 2.1.2.

4.4 The net section of plates for all tension joints shall be designed using the basic tensile design value of the metal adjusted for the plate tension efficiency factor. Plate tensile design values may be increased by 33⅓ per cent for wind or earthquake loads, but in no case shall the tensile design values be exceeded for dead load and other live loads.

4.5 The net shear section of plates for all heel joints and other joints involving shear, shall be designed using the plate shear design value adjusted for the plate shear efficiency factor. Plate shear design values may be increased by 33⅓ per cent for wind or earthquake loads but in no case shall the shear design value be exceeded for dead load and other live loads.

4.6 Joints resisting compressive forces may be designed to transmit up to 50 per cent of the compressive force through wood to wood compression. The plate area must develop at least 375 pounds axial force per member.

4.7 The basic design values (lateral resistance) for plates installed in lumber pressure-impregnated with fire retardant chemicals shall be reduced from the values determined using untreated lumber.

4.8 Splice plates in the top and bottom chord located within 12 inches of a calculated point of inflection may be designed for axial forces only. In trusses supported only at the ends, splices are not recommended within panels that are adjacent to heel joints.

4.9 At all joints, members shall have connector plates sized and/or positioned so that the allowable axial stress (F_c or F_t), of the wood member, is not exceeded on the reduced net section, $h' \times b$ (see figure 5).

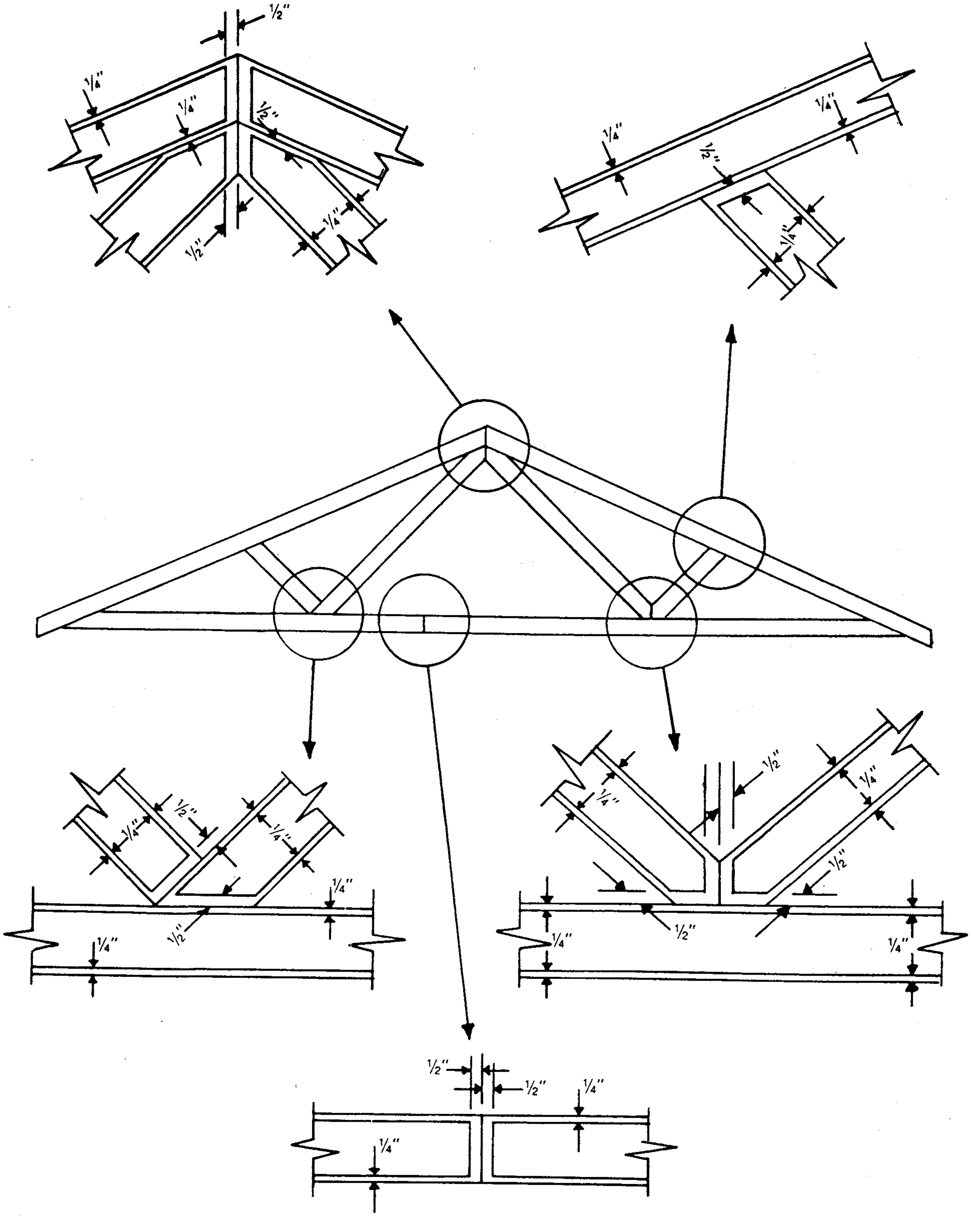


Figure 4 - End and Edge Distances

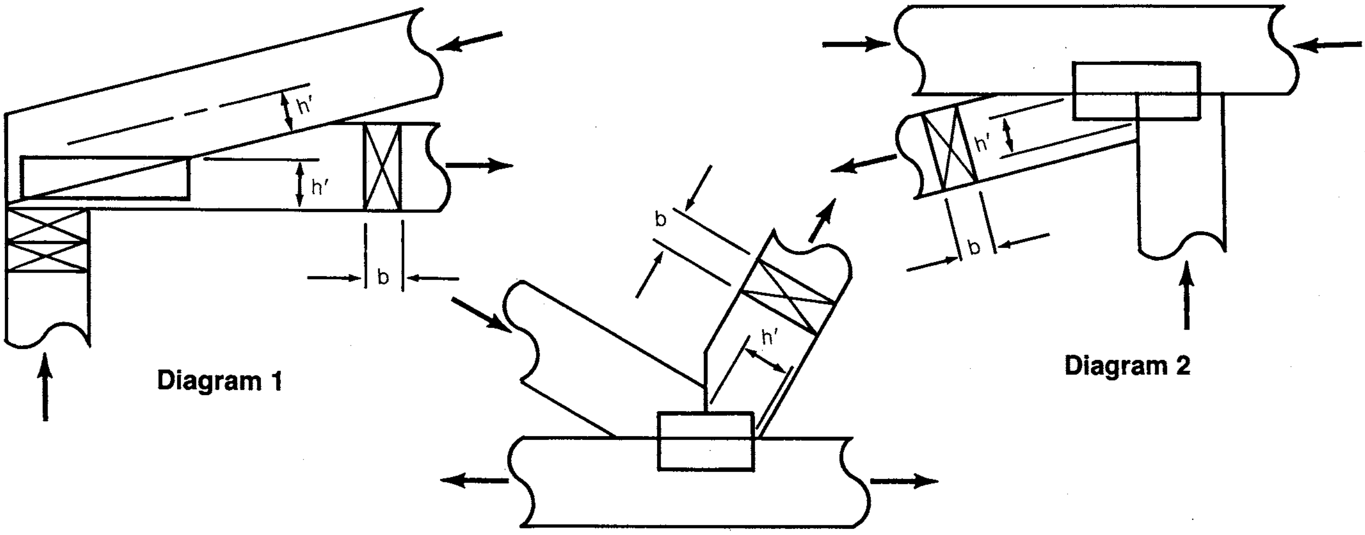


Diagram 1

Diagram 2

Diagram 3

Figure 5

PART V CANTILEVERS

5.1 Cantilevered roof trusses with additional webbing to achieve triangulation are to be designed for the most critical loading, and shall be checked for total load over the entire truss or dead load over the entire truss in conjunction with wind uplift on the cantilever. Each member and each joint are to be designed for the most critical case per 3.3 and 3.4.

5.2 Cantilevered roof trusses without additional webbing to achieve triangulation are to be designed per 3.2, 3.3 and 3.4 as end bearing trusses using overall bottom chord length as the design span. If the butt cut is greater than 0.25 inches, extrapolate and use as design span an overall bottom chord length based on a 0.25 inch butt cut.

(A) When there is no reinforcement or only a wedge at the heel, the capacity of the top and bottom chords to carry the eccentric moment at the crotch or inside end of the wedge respectively, shall be checked by the following set of equations:

$$\frac{M_T}{SF_b} + \frac{P_T}{AF_c'} \leq 1.00$$

$$\frac{M_B}{SF_b} + \frac{P_B}{AF_T} \leq 1.00$$

$$M_T = \frac{w_T(L_T - L_D)^2}{2} + H_E (L_T - L_D) \tan \theta - V_E (L_T - L_D)$$

$$M_B = \frac{w_B(L_B - L_D)^2}{2} - V_A (L_B - L_D)$$

$$P_T = H_E \cos \theta + V_E \sin \theta - w_T \sin \theta (L_T - L_D)$$

$$P_B = - H_E$$

$$H_E = \left(\frac{w_T L_T}{2} + \frac{R_T L_C}{L_T} + \frac{w_B L_B}{2} + \frac{R_B L_C}{L_B} - R_G\right)\Big/\tan \theta$$

$$V_A = \frac{w_B L_B}{2} - \frac{R_B L_C}{L_B}$$

$$V_E = \frac{w_B L_B}{2} + w_T L_T + \frac{R_B L_C}{L_B} - R_G$$

$$R_T = (R_G D4 - D3 + D1)/(D2 + D4)$$

$$R_B = R_G - R_T$$

$$D1 = w_T L_C(L_T^3 - 3L_T L_C^2 + 2L_C^3)/(48(EI)_T \cos^2 \theta)$$

$$D2 = L_C^2(L_T - L_C)^3(3L_T + L_C)/(\cos \theta (EI)_T 12 L_T^3)$$

$$D3 = w_B L_C(L_B^3 - 3L_B L_C^2 + 2L_C^3)/(48(EI)_B)$$

$$D4 = L_C^2(L_B - L_C)^3(3L_B + L_C)/(12(EI)_B L_B^3)$$

$$L_B = \text{LARGER OF } L_{1B} + L_H, \text{ OR } [(L_{1B} + L_{2B})/2] + L_H$$

$$L_T = \text{LARGER OF } L_{1T} + L_H, \text{ OR } [(L_{1T} + L_{2T})/2] + L_H$$

Set $L_D = L_H$ when no wedge is used.

When no reinforcement is used, the entire bearing must be located under the scarf:

$$L_H \geqslant L_C + B$$

When a wedge is used, it shall be so proportioned that:

$$L_R \geqslant L_C - L_H + B$$

but shall not exceed a 2×4, 2×6, 2×8, 2×10, and 2×12 for a 2/12, 3/12, 4/12, 5/12, and 6/12 slope respectively.

The wedge shall be one solid piece cut from #2 or better lumber, shall be placed with longitudinal grain parallel to the bottom chord, and shall fit tightly at the crotch with no gaps longer than six inches or wider than one-eighth inch. The wedge shall be plated to the top and bottom chord with one continuous plate, placed over or inside the bearing. For wedges larger than 2×8, two continuous plates shall be used, located at the midpoint and inside end of the wedge. The plate(s) must be at least 3 inches wide and long enough to contact at least 2.5 inches of each chord. For trusses with 2×6 or larger chords using a 2×6 or larger wedge, the plate(s) must be at least 4 inches wide and long enough to contact at least 3.5 inches of each chord. Wedge plate orientation shall be vertical. The heel plate must have the same shear and lateral resistance capacity as that required for a similar end bearing truss.

(B) When a reinforcing member is used at the heel, its size shall be determined from Table 5.1. It shall be #2 or better lumber. A reinforcing member larger than 2×8 shall use 2×8 values.

The minimum length of a top chord reinforcing member shall be determined from the following formula:

$$\frac{0.5\,(L_T - L_C) + (L_C - L_H)}{\cos\theta}$$

The minimum length of a bottom chord reinforcing member shall be determined from the following formula:

$$0.67\,(L_B - L_C) + (L_C - L_H)$$

The heel plate shall have 25% more shear and lateral resistance capacity than that required for a similar end bearing truss and shall connect the reinforcing member to the unreinforced chord. The reinforcing member shall be connected to the reinforced chord at its midpoint and inside end with two equal plates that together equal the capacity of the heel plate. A tie plate should be used to connect the chords together at their ends. See Figure 7.

TABLE 5.1 Maximum Reinforcing Member Cantilever[1]

BOTTOM CHORD	SLOPE	REINFORCING MEMBER		
		2 × 4	2 × 6	2 × 8
		L_K	L_K	L_K
2 × 4	2/12	39	51	60
	3/12	25	33	40
	4/12	18	24	30
	5/12	14	19	23
	6/12	12	16	19
2 × 6	2/12	51	60	60
	3/12	33	41	48
	4/12	24	30	36
	5/12	19	23	28
	6/12	16	20	23
2 × 8	2/12	60	60	60
	3/12	40	48	55
	4/12	30	36	41
	5/12	23	28	32
	6/12	19	23	27

[1] Based on 3½" bearing, ¼" butt cut and equation given below

$$L_K = \frac{(d_B + d_R - \text{butt cut})}{\tan\theta} - \frac{1}{2}B_R$$

and $L_K \leq 60''$

where: d_B = bottom chord width
d_R = reinforcing member width
and maximum butt cut = 1.00"

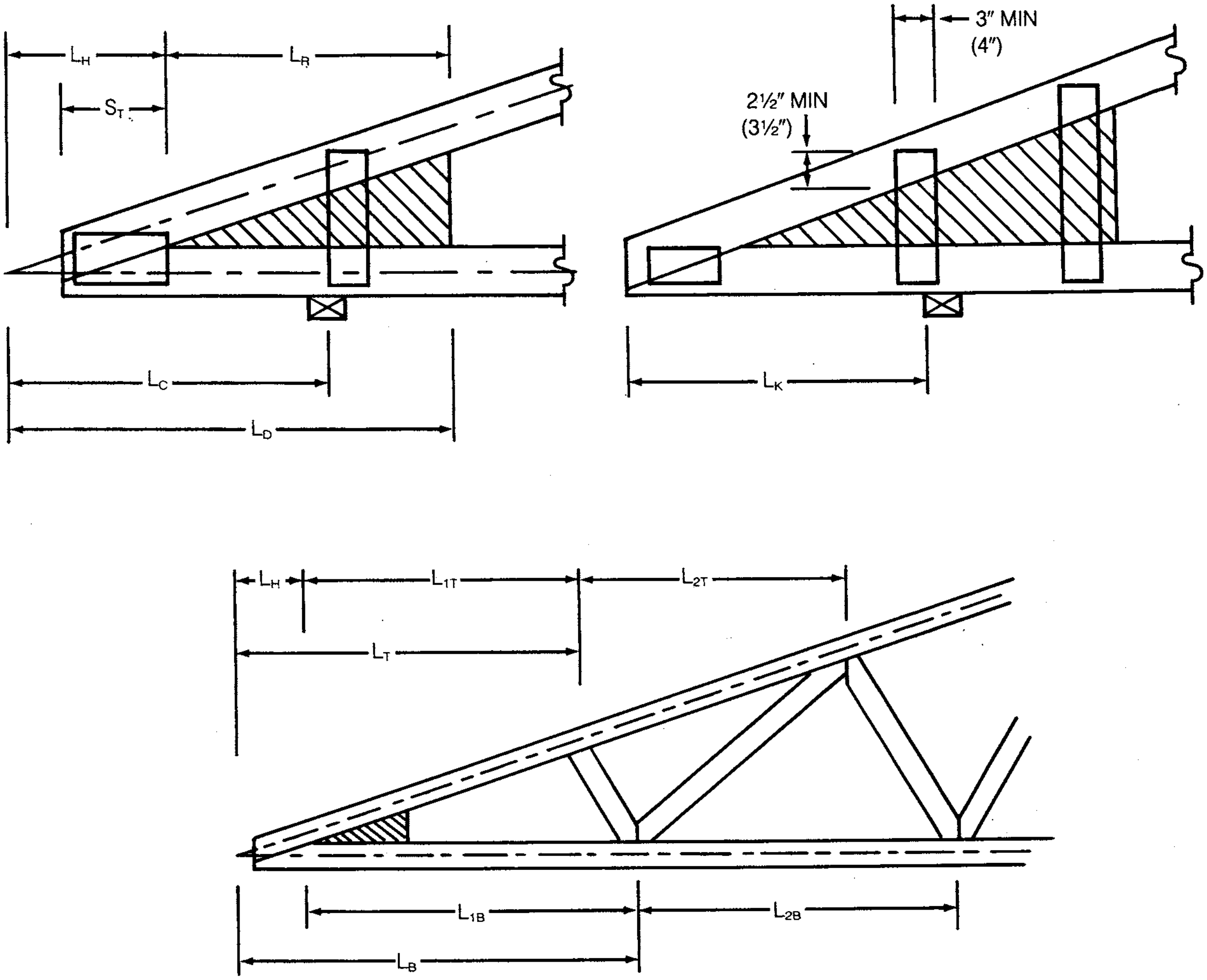


Figure 6 - Wedge Cantilever Details

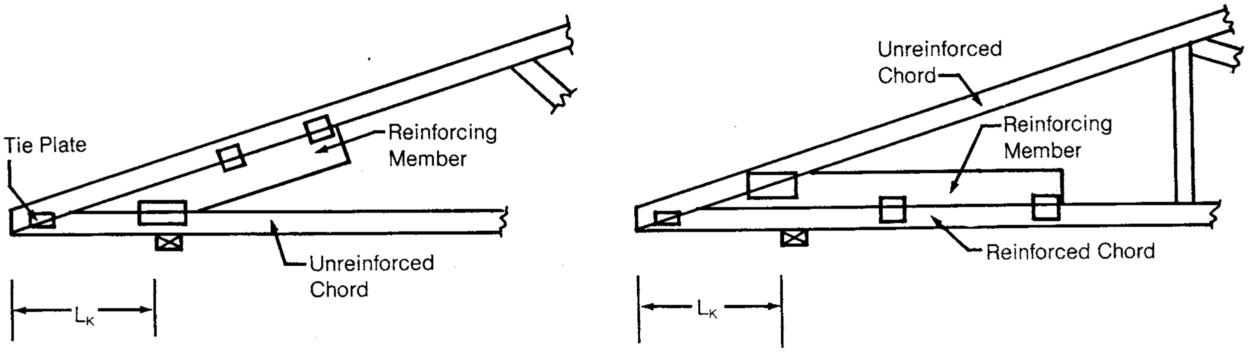


Figure 7 - Reinforcing Member Cantilevers

PART VI MISCELLANEOUS

6.1 Wind Loading

All truss designs shall be analyzed for wind loads when the wind uplift exceeds the total dead load or when the positive wind load plus dead load creates a more critical loading combination than the combination of other design loads.

6.2 Roof Truss Deflection

The portion of the total truss deflection due to live load shall not exceed $L_s/360$ when plaster is used nor $L_s/240$ when flexible type ceiling such as dry-wall or a suspended ceiling is used. For cantilever trusses, the above figures shall be $L_k/180$ when plaster is used and $L_k/120$ when flexible type ceiling or a suspended ceiling is used. See Figures 1, 6, 7 and 8. The deflection for trusses without a finished ceiling shall not exceed $L_s/180$.

6.3 Camber

In order to maintain a uniform ceiling height, it is customary to provide sufficient camber in the lower chord to compensate for normal dead load deflection.

6.4 Anchorage

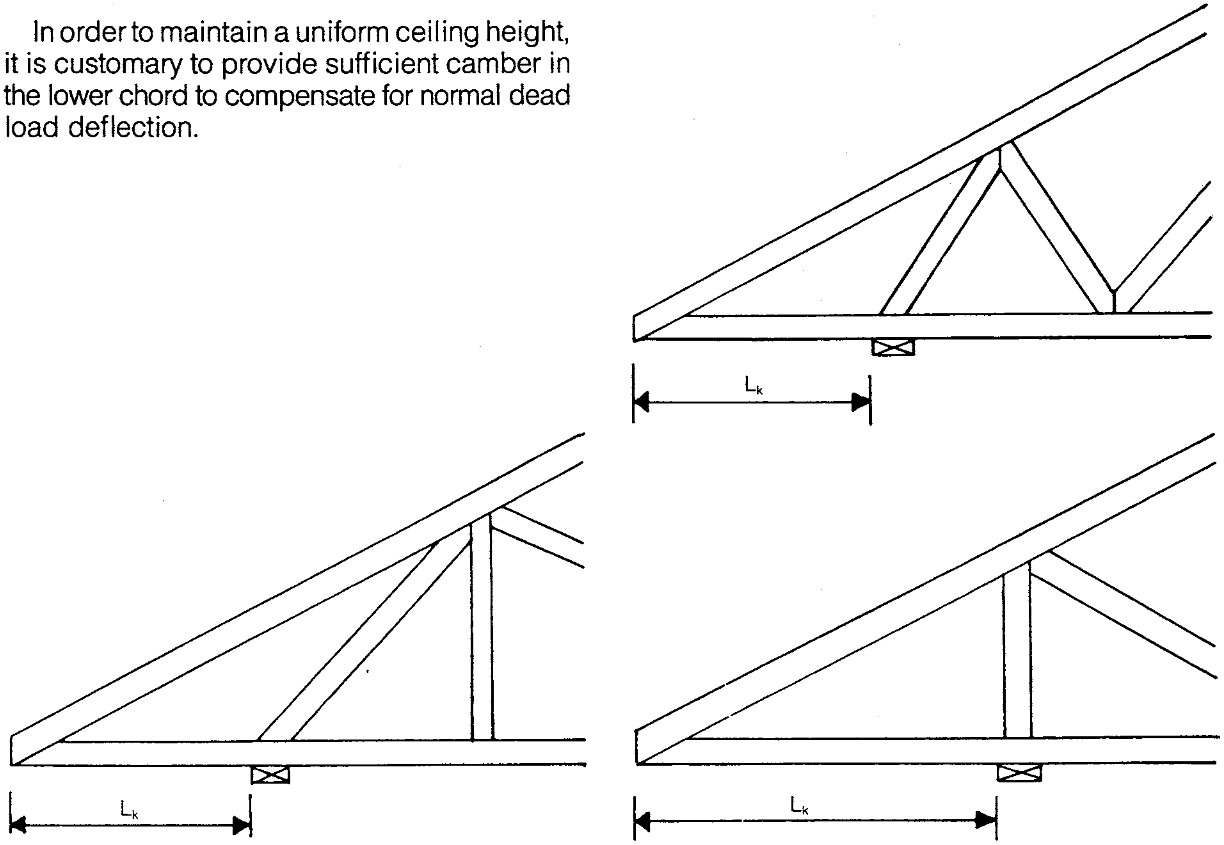
Trusses shall be securely anchored to all bearings utilized in the design and shall be adequately secured to resist any uplifting reactions developed under section 3.1.2, otherwise these bearings shall not be utilized in the determination of axial forces. Suitable provisions for anchorage must be made by those responsible for the overall building design.

6.4 Load Test of Full Size Trusses

Load tests shall be conducted as shown in Appendix D.

6.6 Plate Evaluation

Plate design values shall be determined in accordance with the test method and evaluation procedure contained in Appendix C,D,E,F.



Note: Web configuration may vary from these shown.

Figure 8 — Typical Cantilevers

APPENDIX A

RECOMMENDED MINIMUM DESIGN LOADS

A.1 General

These loads are suggested in the absence of other design criteria more suitable to the area or conditions of use. Certain applications may permit lower loads while others may require higher values; local conditions should be investigated before proceeding with the design.

Loads as specified herein are recommended for metal plate connected wood trusses. They shall be based on the horizontally projected area and applied vertically. In no case shall the weight of the truss be neglected in its design.

See American National Standards Institute Standard A 58.1 for more detailed, recommended design loads.

A.2 Gravity Loads

A.2.1 Top chord live load is considered as snow, rain, wind or any other load which may be removed or is not permanently attached to the top chord.

A.2.2 Bottom chord live load

Habitable attics	30 PSF
Uninhabitable attics	20 PSF
Accessible attics	See A.2.7
Non-Accessible Ceilings	No live load

A.2.3 Top chord dead load: actual weight of material but not less than 7 PSF for residential use.

A.2.4 Bottom chord dead load: actual weight of material but not less than 10 PSF for residential use.

A.2.5 Habitable attics are herein defined as attic spaces served by a stair and capable of containing a rectangular prism 7 feet high by 6 feet wide by 8 feet long, free of truss structural members. See Figure A-1. Live load shall be applied over entire length of panel containing above rectagular prism.

A.2.6 Uninhabitable attics are herein defined as attic spaces served by a stair, having a minimum clear height greater than 6 feet, but not capable of containing the prism described in A.2.5. See Figure A-2.

A.2.7 Accessible attics are herein defined as those served by a scuttle. Bottom chord minimum total load is 10 PSF.

A.2.8 Non-accessible ceilings are herein defined as those with no means of access.

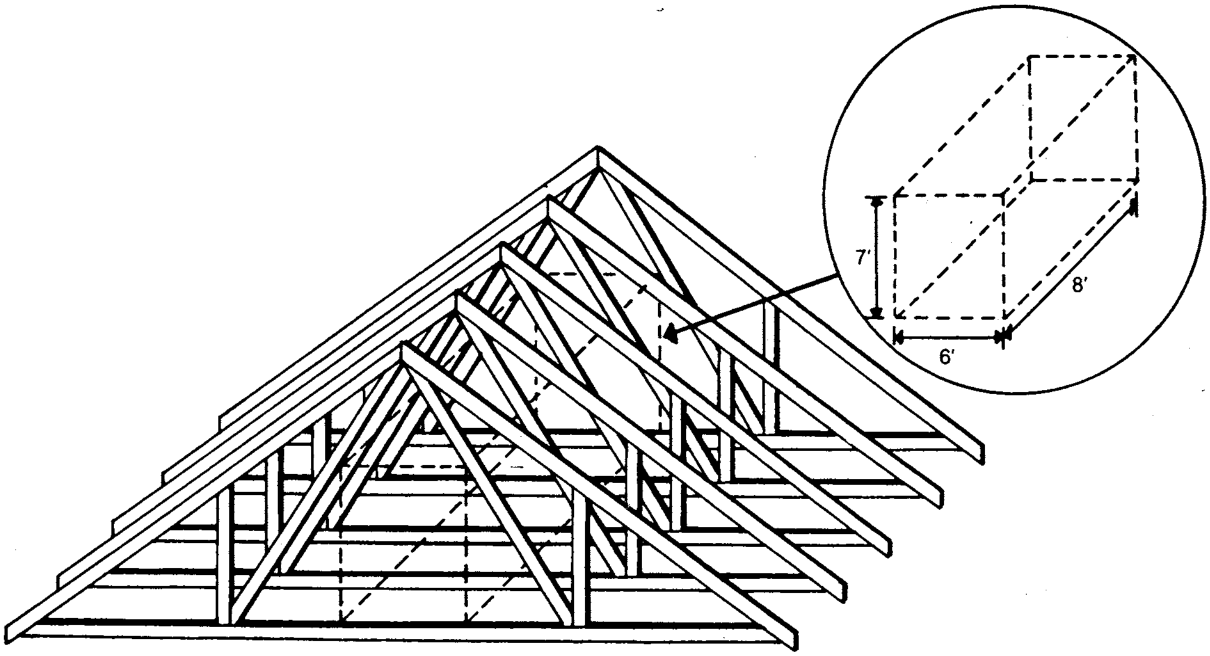
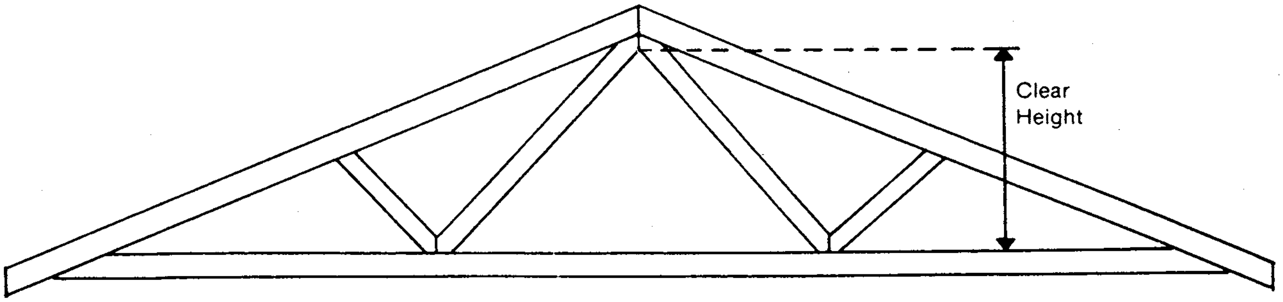


Figure A-1



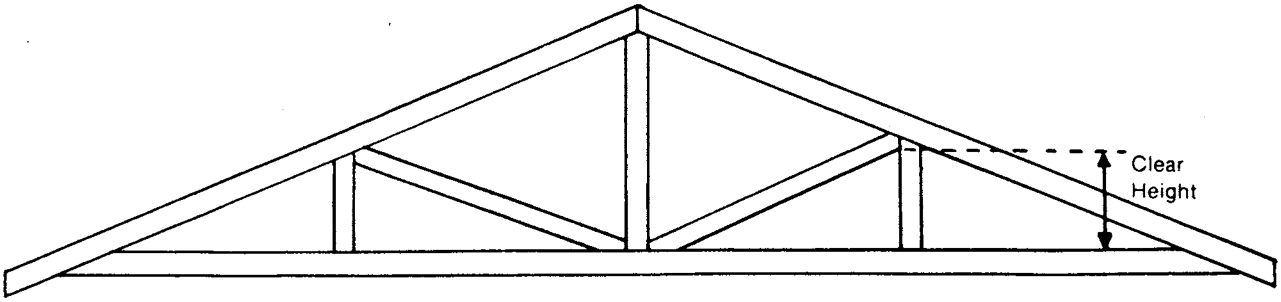


Figure A-2

APPENDIX B

COMMENTARY ON BRACING

TPI *Design Specification for Metal Plate Connected Wood Trusses* is to be used for the design of individual wood trusses as structural components only.

The need for and location of lateral bracing that may be required to reduce the buckling length of individual truss members is determined as a part of the wood truss design and is the only requirement for bracing that will be shown on the truss design. Lateral bracing details, including method of connection and transfer of member buckling forces to the structure, are to be determined by the building designer. Lateral bracing is to be supplied in the size specified and installed at the location specified by the builder or erection contractor. The building designer must ascertain that the specified lateral bracing is properly installed and that this bracing is sufficiently anchored or restrained by diagonal bracing to prevent its movement.

Special design requirements, such as wind bracing, portal bracing, seismic bracing, diaphragms, shear walls, or other load transfer elements and their connections to the wood trusses must be considered separately by the building designer. The building designer shall determine size, location, and method of connections for diagonal bracing as needed to resist these forces. Diagonal or cross bracing is recommended in the plane of the top chord, in the plane of the bottom chord, and perpendicular to the truss web member, as needed for the overall stability of the entire structure. Truss bracing and connection details should be shown on the building designer's framing plan as part of the design drawings. Bracing materials are not usually furnished as part of the wood truss package, and should be included by the builder or erection contractor.

The builder or erection contractor is responsible for proper wood truss handling and for proper temporary bracing. He must assure that the wood trusses are not structurally damaged during erection and that they are maintained in alignment before, during, and after installation. Temporary or erection bracing may follow, but not necessarily be limited to, the permanent bracing design prepared by the building designer.

The design of wood trusses in accordance with TPI design criteria assumes:

1. Truss members are initially straight, uniform in cross section, and uniform in design properties.
2. Trusses are planar structural components, installed vertically, braced to prevent lateral movement, and parallel to each other at the design spacing.
3. Truss members are pinned at joints for determination of axial forces only.
4. Compression members are laterally restrained at specific locations or intervals.
5. Superimposed dead or live loads act vertically, wind loads are applied normal to the plane of the top chord, and concentrated loads are applied at a point.
6. The building designer will specify sufficient bracing at right angles to the plane of the truss to hold every truss member in the position assumed for it in design.
7. The building designer will specify sufficient bracing and connections to withstand lateral loading of the entire structure.

For additional information see *Bracing Wood Trusses: Commentary and Recommendations* (Reference 12, Appendix G).

APPENDIX C

Effective until December 31, 1985

CONNECTOR PLATE TEST METHOD AND EVALUATION PROCEDURE

C.1 General

C.1.1 Basic nail values (lateral resistance) for use in designing wood joints using metal connector plates, per tooth, nail, plug, square inch, or other unit, shall be determined by the following standardized test procedure which is based on the load at the limiting value of 0.015 inch slip, or ultimate load with appropriate adjustment factors applied.

C.1.2 The drawing shown in Figure C details the limits for the dimension of the test specimens and alternate test arrangements. The critical slip of 0.015 inch is measured from connector to each active wood member or when measured from wood to wood, the critical slip is 0.030 inch.

C.2 Test Specimens

Ten specimens shall be fabricated from commercially available grades of each of the species groups, as listed in Table 8.1A of NDS, intended for use in fabrication of trusses with the tested connector plate. Five specimens shall be designated as control specimens and five as moisture response specimens. The average specific gravity of the ten specimens shall be within ± 10 per cent of the species value listed in the NDS, and this property shall be recorded with the other test data. The test specimens shall be cut and match-marked so that substantially equal characteristics are represented in each of the control and moisture response groups.

C.3 Moisture Content

C.3.1. The five control specimens shall be fabricated and tested at a wood moisture content of 15 per cent ± 4 per cent.

C.3.2 The five moisture response specimens shall be fabricated at a wood moisture content of not less than 15 per cent. The specimens shall be dried to a moisture content of 7 per cent or less within 5 days and then returned to moisture content of not less than 10 per cent before testing.

C.4 Methods of Test

Each tensile specimen shall be tested to failure in a calibrated testing machine. Tests shall be supervised and reported by a recognized independent testing laboratory or an independent Registered Professional Engineer. Test specimen arrangement is as shown in Figure C. Wood members may be clamped in the jaw of the testing machine. Where keeper nails are used in the fabrication process and are intended to be used in production trusses, they shall be installed and included in the evaluation specimen. Dial gauges having least readings of 0.001 inch shall be used, and shall be placed on opposite sides of the specimen as shown in Figure C. Certification of calibration of the testing machine shall be made available on request. Tests shall be conducted to achieve maximum load in about 10 minutes, but reach maximum load in not less than 5 nor more than 20 minutes. A rate of motion of the movable crosshead of 0.0035 inches per minute, ± 50 per cent, will usually permit reaching maximum load in the prescribed time. Record the speed used. Readings shall be taken so as to obtain not less than three increments of load before the slip of 0.030 inch (wood to wood) has been reached. Readings shall include total load applied, and amount of slip indicated by each dial gauge. Application of load shall continue at the original rate of application until failure occurs. Type of failure shall be noted for each specimen (See Reference 8, Appendix G.)

C.5 Evaluation of Test Results

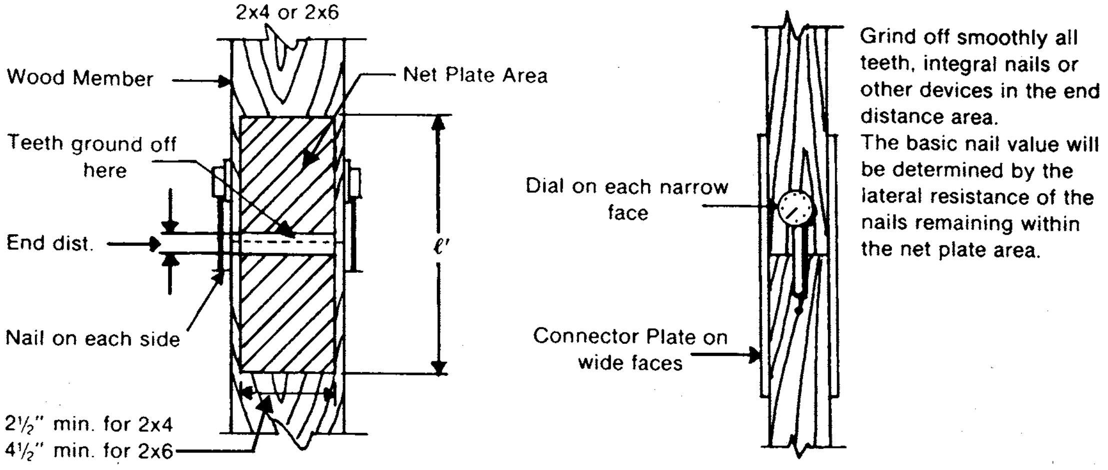
C.5.1 The calculated value per tooth, nail, plug or square inch of plate for each specimen tested for normal loading, shall be calculated by dividing the average load of the:

(a) 5 control specimens at critical slip by 1.6
(b) 5 moisture response specimens at critical slip by 1.33
(c) 5 control specimens at ultimate by 3.0
(d) 5 moisture response specimens at ultimate by 2.5

C.5.2 For a given species average the 5 specimen values determined for each of the four calculations above. The basic design value per tooth, nail, plug or square inch of plate for said species shall be the least of these four values.

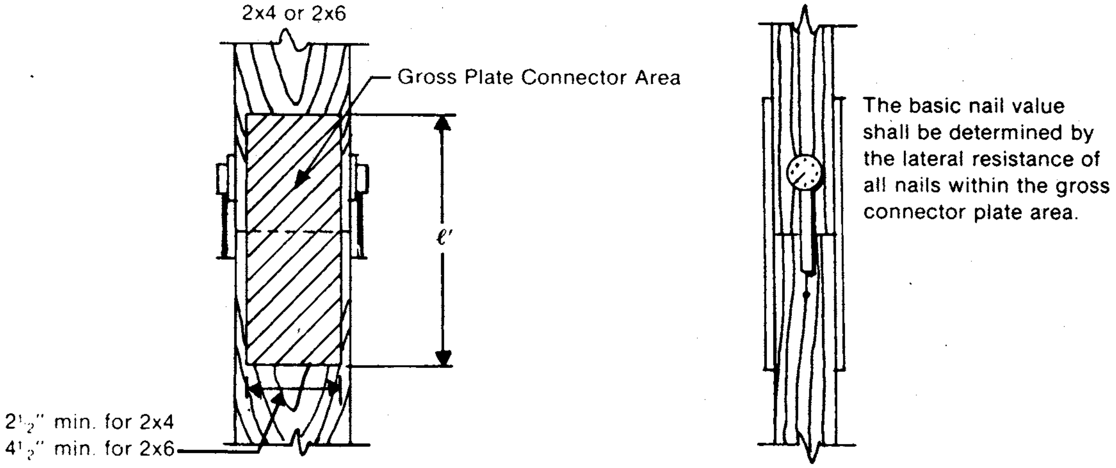
C.6 Report

Recommended record and evaluation forms are included in Appendices K and L.



Grind off smoothly all teeth, integral nails or other devices in the end distance area.
The basic nail value will be determined by the lateral resistance of the nails remaining within the net plate area.

Net Plate Area Method



The basic nail value shall be determined by the lateral resistance of all nails within the gross connector plate area.

Gross Plate Area Method

Note: ℓ' is length to induce tooth withdrawal rather than tearing

Figure C - Standard Connector Evaluation Tension Test

APPENDIX C

Effective Jan 1, 1986

TRUSS CONNECTOR PLATE TEST METHOD AND EVALUATION PROCEDURE

C.1 General

C.1.1 Lateral resistance values for use in designing wood joints using metal connector plates, per tooth, nail, plug, square inch, or other unit, shall be determined by the following standardized test procedure which is based on the load at the limiting value of 0.015 inch slip, or ultimate load with appropriate adjustment factors applied.

C.1.2 The drawings shown in Figure C-1 and C-2 detail the limits for the dimension of the test specimens and alternate test arrangements. The critical slip of 0.015 inch is measured from connector to each active wood member or when measured from wood to wood, the critical slip is 0.030 inch.

C.2 Test Specimens

Twenty specimens shall be fabricated from structural lumber grades of each of the species, as listed in table 8.1A of NDS, intended for use in fabrication of trusses with the tested connector plate. Ten specimens shall be fabricated with tooth orientation as shown Fig. C-1 and ten specimens shall be fabricated with the plate rotated 90 degrees as shown Fig. C-2. For plate types that are symmetrical about both axis e.g. plug-type, only ten specimens are required. The average specific gravity of the ten specimens shall not exceed the published average of the species value listed in NDS with no more than two specimens exceeding the listed specific gravity by no more than 10 percent. The test specimens shall be cut and match-marked so that substantially equal characteristics are represented in each of the groups. After the specimens are assembled they shall be stored for a minimum of one week before being tested.

C.3 Moisture Content

The ten specimens shall be assembled and tested at a wood moisture content of 15 percent ±4 percent.

C.4 Steel Specifications

C.4.1 Three steel coupons shall be taken from each end of each slit coil utilized to make the perforated plates. (See method E.8 for dimensions.) Steel coupons shall be tested in accordance with the provisions of Appendix E.

Steel thickness shall not exceed a maximum of 5 percent greater than specified minimum.

C.5 Methods of Test

Each tensile specimen shall be tested to failure in a calibrated testing machine. Tests shall be supervised and reported by a recognized independent testing laboratory or an independent Registered Professional Engineer. Test specimen arrangement is as shown in Figure C wood members may be clamped in the jaw of the testing machine. Where keeper nails are used in the fabrication process and are intended to be used in production trusses, they shall be installed and included in the evaluation specimen. Dial gauges having least readings of 0.001 inch shall be used, and shall be placed on opposite sides of the specimen as shown in Figure C. Certification of calibration of the testing machine shall be made available on request. Tests shall be conducted to achieve maximum load in about 10 minutes, but reach maximum load in not less than 5 nor more than 20 minutes. A rate of motion of the movable crosshead of 0.0035 inches per minute ±50 percent, will usually permit reaching maximum load in the prescribed time. Crosshead speed shall not exceed .01 inches per minute. During the test under no conditions can the crosshead speed be increased. The speed may be reduced to require a minimum test time of 5 minutes. Record the speed used. Readings shall be taken so as to obtain not less than three increments of load before the slip of 0.030 inch (wood to wood) has been reached. Readings shall include total load applied, and amount of slip indicated by each dial gauge. Application of load shall continue at the original rate of application until failure occurs. Type of failure shall be noted for each specimen. (See Reference 8, Appendix G.)

C.6 Evaluation of Test Results

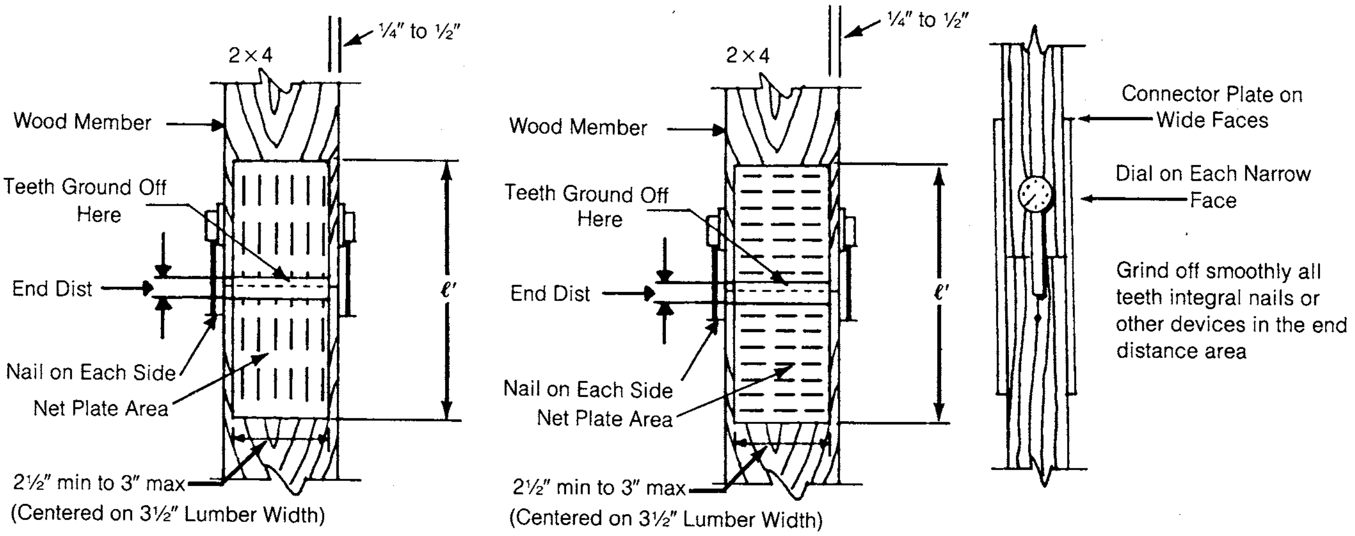
C.6.1 The calculated value per tooth, nail, plug or square inch of plate for each specimen tested for normal loading, shall be calculated by dividing the average load of the:

A. 10 specimens at critical slip by 1.6
B. 10 specimens at ultimate by 3.0

C.6.2 For a given species average the 10 specimens values determined for each of the calculations above. The basic design values per tooth, nail, plug or square inch of plate for said species shall be the least of these two calculated averages. This shall be done for both 0 degrees and 90 degrees orientation. The basic design values, both 0 degrees and 90 degrees can be used for any other lumber species of equal or greater density listed in the same lumber group. (Table 8.1A NDS)

C.7 Report Forms

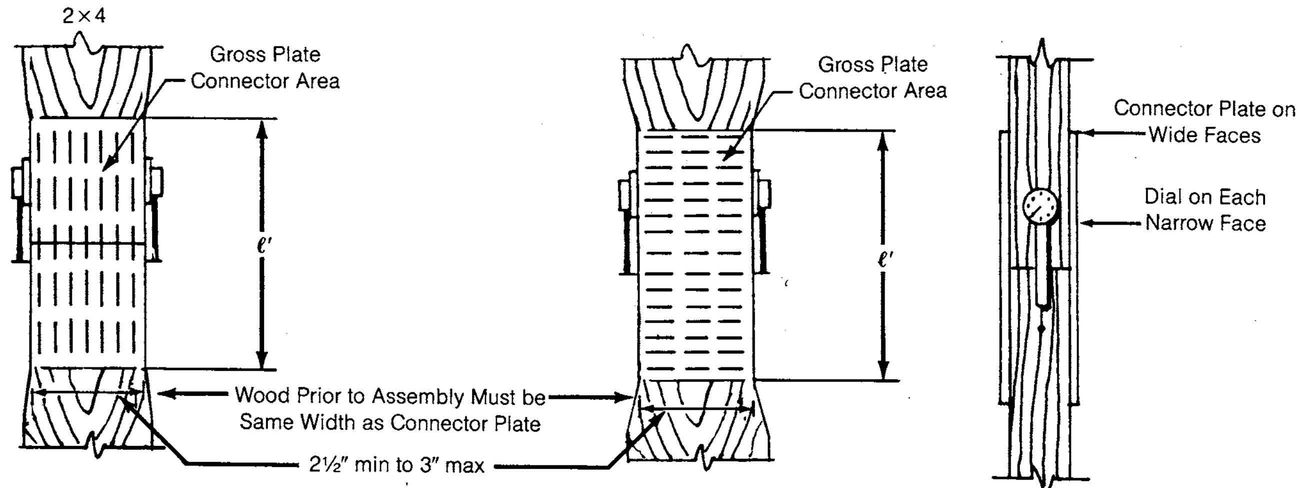
Recommended record and evaluation forms are included in appendices K and L.



0° Plate Orientation
C-1

90° Plate Orientation
C-2

Net Plate Area Method



2×4
Gross Plate Connector Area
ℓ′
Gross Plate Connector Area
ℓ′
Wood Prior to Assembly Must be Same Width as Connector Plate
2½″ min to 3″ max
Connector Plate on Wide Faces
Dial on Each Narrow Face

0° Plate Orientation
C-1

90° Plate Orientation
C-2

Gross Plate Area Method

Note: ℓ′ is length to induce tooth withdrawal rather than tearing

Figure C - Standard Connector Evaluation Tension Test

APPENDIX D

LOAD TEST OF FULL SIZE TRUSSES

D.1 General

D.1.1 Load tests of full scale trusses may be used to verify the performance characteristics of specific metal connector plates, various lumber types and grades, a particular truss design, and preservative or fire retardant treated wood.

D.1.2 The objectives of the load tests are to verify performance as described on D.1.1 and to eliminate the need at later times for the performance testing of each truss configuration in order to qualify all spans and slopes of trusses to be designed in accordance with TPI Design Specifications, and to enable the design of trusses without the need for continued testing.

D.1.3 Full scale load tests shall be performed on trusses designed to the most recent TPI Design Specifications. The test trusses shall be designed so that critical members and joints will be stressed as closely as practical to the design values of the lumber and plates at the time the design load is applied.

D.1.4 Testing shall be witnessed by an approved independent testing laboratory or independent Registered Professional Engineer and shall meet or exceed standards set forth in section D.4 or D.5.

D.1.5 Whenever possible, load testing shall be conducted under cover. When this is not possible or feasible, adequate weather protection shall be furnished to prevent adverse effects of moisture on the wood trusses and to prevent variation of the load caused by the absorption of water by the loading units. Loading units shall be separated to prevent the possibility of arch action.

D.1.6 Trusses may be tested in pairs or singly; however, in either case a minimum of three units would be tested when done singly, three set-ups when done in pairs.

D.1.7 Trusses shall be fabricated at least one week prior to testing.

D.2 Testing in Pairs

D.2.1 The test units shall be supported on firm stable reactions. They shall be spaced at the spacing for which they were designed. Experience has shown that properly securing the trusses to the reaction is recommended for safety. Use of strapping or metal framing connectors is suggested to resist tipping of the units during the load application. The top chords shall be sheathed with 4 to 6 foot lengths of any of the generally accepted sheathing materials (boards, plywood, reconstituted panel products, etc.). In any case, each piece shall be separated at least ⅛". A recommended practice is to use cross-bracing between the trusses to stabilize the set-up; however, the trusses shall not be braced by tieing the set-up to adjacent permanent supports or other supports which may affect the free deflection of the trusses.

D.2.2 Deflection readings shall be taken and recorded for each truss as required for the purpose of the tests. For laboratory and investigative testing, it may be necessary to record deflection at all panel points, at the center of the trusses and at the mid-point of each lower chord panel, and at other locations that may be specified. Deflection readings may be averaged between each pair of trusses at corresponding locations.

D.2.3 Deflection measurements may be taken by any one of several methods; however, experience has shown that more accurancy is obtained when the gages are independent of the support reactions. This is best accomplished by line, scale and mirror arrangement. The line is supported on free-rolling bearings and kept under tension by means of weights. When the tests are conducted where temperature conditions change, using a braided fish line is recommended. Under controlled laboratory conditions, piano wire or monofilament line will suffice. Deflection readings are taken by reading on the scale, which is attached to the truss, adjacent to the line. Adjusting the eye position so that the line covers its image in the mirror removes parallax from the scale reading. Scale readings may then be referenced to either the top or bottom edge of the line. Dial gages may be used to measure deflection; however, a precise measurement must be taken of settlement at the supports.

The other deflection readings are then subject to correction for settlement.

D.3 Testing Singly

The trusses (a minimum of three trusses) may be tested as single units in either a vertical or horizontal position in a properly designed test facility. The loads may be applied uniformly or at concentrated points along the chords. Wood strips may be attached along the top chords or frictionless brackets or attachments may be used to prevent the load brackets from slipping down the top chords on steep-sloped trusses.

Deflection measurements shall be similar to the procedures described in D.2.2 and D.2.3.

D.4 Load-Deflection Test Procedures

D.4.1 Apply ½ design load and hold for five minutes. This application allows the truss to be settled and provides an opportunity for checking alignment, equipment positioning and overall set-up. This initial preliminary load shall be removed and deflection readings taken within 5-10 minutes. The design dead load is then applied, and after a minimum hold period of five minutes, the deflection readings are taken. Optionally, this dead load may be left in place 24 to 48 hours to establish a basic dead load (BDL) position.

D.4.2 With the dead load applied, increase the load to ¼, ½, ¾ and full design live load. Apply the incremental loads at a uniform rate of loading with a minimum of 5 minutes hold at each load increment. In any event, a minimum of 15 minutes is required to reach design live load.

D.4.3 Continue to load the truss incrementally in quarter live load units to dead load plus 2.0 times the design live load. The truss shall sustain this loading for at least 30 minutes without exceeding a deflection of $L_s/180$ or $l_s/120$ respectively, for plaster and drywall ceilings.

D.4.4 Remove all live load and, within 30 minutes, the truss must recover to a position of $L_s/360$ or $L_s/240$, respectively, relative to BDL. If deflections due to the loads of Paragraph D.4.3 remain within $L_s/360$ or $L_s/240$, respectively, the loading may be increased per D.5.2 without removing the live load. Note: With single truss test using hydraulic cylinders, the dead load may be partially removed so the cylinders retract properly. Then immediately return to BDL.

D.5 Load to Failure Test

D.5.1 Load to failure tests as herein described may be desired after the above load deflection test has been completed.

D.5.2 If D.4.3 or D.4.4 has been satisfied, continue loading in ¼ load increments at 5-minute intervals or longer at manufacturer's option, until failure occurs. At BDL plus 2.5 times design live load, the truss should sustain the load for 5 minutes.

D.6 Reporting Test Results

The written report should include method and location of testing and personnel performing tests. The report should include the lumber grades, lumber moisture content at time of tests, plate type and size at each location. A detailed drawing of the truss, pictures of the set-up and failure location, if it occurred, is recommended.

APPENDIX E

STANDARD METHOD OF TEST FOR TENSILE STRENGTH PROPERTIES OF STEEL TRUSS PLATES[1]

E.1 Introduction

The use of steel truss plates to fasten wood members together is a widely accepted practice. In many applications, the truss plate must resist tensile forces. During manufacture and subsequent loading of the truss plates, stress concentrations develop around holes, teeth, prongs, and barbs. Because of these stress concentrations and the difficulty of predicting the path of failure, design values for truss plates should be based on tests rather than analytical methods.

If a section taken through the width of a truss plate differs from a section through its length, the effectiveness ratio of the plate will be a function of its orientation. If this is the case, the plate shall be evaluated for net section across its length as well as its width under the method presented here. However, if a plate is identical in both directions, only tests across its width shall be necessary and the resulting effectiveness ratio is applicable to both orientations of the plate.

E.2 Scope

E.2.1 This method provides a basic procedure for evaluating the tensile strength properties of the net section of steel truss plates.

E.2.2 The test also provides a basis for determining the comparable performance of different types and sizes of steel truss plates in tension.

Note 1 The maximum design load in tension, an indication of the effectiveness of the net cross section of the perforated metal truss plate, is not necessarily a criterion of the effectiveness of the plate in transmitting the load from wood member to wood member, since that property is influenced by a number of factors, including the effectiveness of the teeth, prongs, and barbs or that of the nails or a combination thereof, used in the species and grade of lumber under consideration in accordance with Method D, 1761

E.3 Applicable Documents

E.3.1 ASTM Standards:

D 1761 *Standard Method for Testing Mechanical Fasteners in Wood*
E 4 *Verification of Testing Machines*
E 8 *Tension Testing of Metallic Materials*

E.4 Summary of Method

E.4.1 This method provides procedures for (1) tension tests of manufactured steel truss plates, (2) tension tests of control plates of the same material used in the manufacture of the truss plates, and (3) a comparison of the truss plates with the control plates in terms of effectiveness. By multiplying the tensile effectiveness ratio by the basic design stress for the plate steel times the cross-sectional area of the truss plate, the maximum design load for the truss plate in tension is determined.

E.5 Significance

E.5.1 The resistance of a steel truss plate to tensile forces is one measure of its ability to fasten pieces of wood together where the tensile forces must be transferred through the truss plate from one piece of wood to another. Factors affecting the performance of the truss plate, neglecting the effects of the truss plate protrusions and of the lumber, are listed as follows: length, width, and thickness of the truss plate; location, spacing, orientation, size, and shape of holes in truss plate; edge distance of holes in truss plate; stress concentrations around projections and perforations of truss plate; and basic properties of the plate steel.

E.6 Apparatus

E.6.1 Testing Machine—Any suitable testing machine capable of imposing tensile forces and having an accuracy of ± 1% when calibrated in accordance with Method E4.

E.6.2 Grips—Any self-centering gripping devices for each specimen end are suitable, that are designed to hold the specimen, to allow accurate specimen positioning, and to provide complete rotational freedom. The grips should be designed so as to allow uniform axial loading of the truss plate across its total cross-sectional area.

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[1] This method is under the jurisdiction of ASTM Committee E-6 on Performance of Building Constructions, and is the direct responsibility of Subcommittee EO6 13 on Structural Performance of Joining and Fastening in Building Constructions. Current edition approved January 8, 1981. Published August 1981.

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E.7 Test Material

E.7.1 Truss Plate—The truss plate shall be typical of production, manufactured in accordance with design, and of materials specified by the manufacturer.

E.7.2 Control Plates—The control plate material shall be from an adjacent area of the same slit coil and of the same finish as the manufactured truss plate.

E.8 Sampling

E.8.1 Sampling shall provide for selection, on an objective and unbiased basis, of representative test specimens made of material taken from several batches of steel. Truss plate sampling should be from typical production manufacturing and should take into account the different widths and thicknesses of plates produced as follows for each thickness and for each configuration of plates:

E.8.1.1 For tests across the plate width: six truss plates of each of two different widths.

E.8.1.2 For tests across the plate length: six truss plates of a single plate length.

E.8.1.3 For control plates: three solid plates from each slit coil utilized to make the perforated plates in E.8.1.1 and E.8.1.2.

Note 2—The justification for testing only a single plate length, whereas two plate widths are specified, lies in the method of manufacture. As plates are formed in a continuously-fed stamping operation, their length module is repetitive and uniform. Hence, the edge distance of holes is constant regardless of plate length. However, the width of the plate may be varied in manufacture so that the edge distance is not constant for different plate widths.

E.9 Test Specimen

E.9.1 Truss Plates—Truss plates chosen for evaluation of the net section across the plate width shall be firmly embedded in a standard tensile joint (plate on both sides without removal of any teeth) so that the plate width is perpendicular to the grain of the lumber (see Figure 1). The truss plates chosen for evaluation across the plate length shall be similarly embedded, except that the plate length shall be perpendicular to the grain of the lumber (see Figure 2). In both cases, the plates should be sufficiently long to induce a tensile failure of the plate metal, rather than a failure by tooth, prong, or barb withdrawal. Alternatively, the plates may be clamped a minimum of 2 inches (51 mm) from the joint to prevent withdrawal.

E.9.2 Control Specimen—The control specimens shall be machined into standard rectangular test specimens (see Figure 3) and tested in accordance with Method E8. Care must be taken to ensure a uniform stress distribution and to prevent premature failure of the specimen in the grips of the testing machine.

E.10 Procedure

E.10.1 General—Measure all specimens before testing to determine their gross width and thickness to the nearest 0.001 inch (0.025 mm). Take measurements at least at three different locations on each specimen.

E.10.2 Testing—Conduct tests in accordance with Method E8 where applicable. Where required, use special grips. Apply the load throughout the test at a uniform rate of separation of the platens of the testing machine so that the maximum load is reached in not less than 60 seconds.

E.10.3 Data Required—For the perforated specimens and control specimens, observe the yield-point loads (for the perforated specimens, if obtainable) and maximum loads in pounds-force (or newtons) with an accuracy corresponding to the smallest graduation on the load scale of the testing machine used.

E.11 Calculations

E.11.1 Calculate the maximum tensile stress of the individual truss plate and solid-section control specimen by dividing the maximum load by the average gross cross-sectional area of each specimen.

E.11.2 Calculate the effectiveness ratio by dividing each truss-plate tensile stress by the matched solid-section tensile stress.

E.11.3 Determine the average tensile effectiveness ratio both across the width and the length of the plate.

E.12. Report

E.12.1 The report shall include the following information:

E.12.1.1 Date of test and date of report,

E.12.1.2 Test sponsor and test agency,

E.12.1.3 Identification of test specimens: manufacturer, model, type, material, finish, shape, dimensions, and other pertinent information, such as cracks and other defects.

E.12.1.4 Detailed drawings or photographs of test specimens before and after testing if not fully described otherwise,

E.12.1.5 Complete description of test method and loading procedure used if there are any deviations from the prescribed or recommended methods as outlined in this standard.

E.12.1.6 Number of specimens tested,

E.12.1.7 All test data, including maxima, minima, and averages,

E.12.1.8 Effectiveness ratios for each individual test specimen, and average values for all identical test specimens,

E.12.1.9 Description of type and path of failure.

E.12.1.10 Summary of findings, and

E.12.1.11 Listing of observers and signatures of responsible persons.

E.13 Design Tension Strength

Allowable design values in tension (pounds per linear inch of height) may be determined by the following formula:

$V_t = (R_{st}F_{st}T_1)2$ for a pair of plates, one on each face of the joint.

E.14 Definitions

R_{st}	Tensile Effectiveness Ratio
F_{st}	Basic Allowable Tensile Stress in Steel
T_1	Basic Metal Thickness of perforated plate & solid control plate after deducting coating thickness, divided by 0.95.
V_t	Allowable design value in tension (pound per linear inch of plate).

E.15 Precision and Accuracy

Neither the within-laboratory not the between-laboratory precision and accuracy of this method has been established.

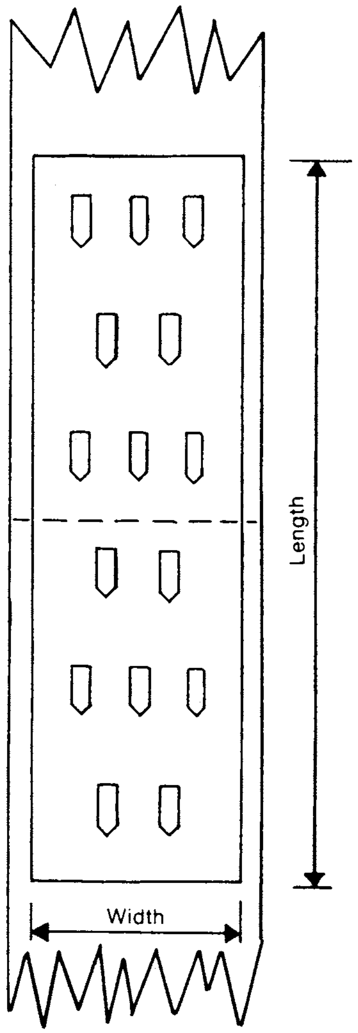

Figure E-1 - Truss Plate Width Perpendicular to Grain of Lumber (for Dimensions, see Method D 1761).

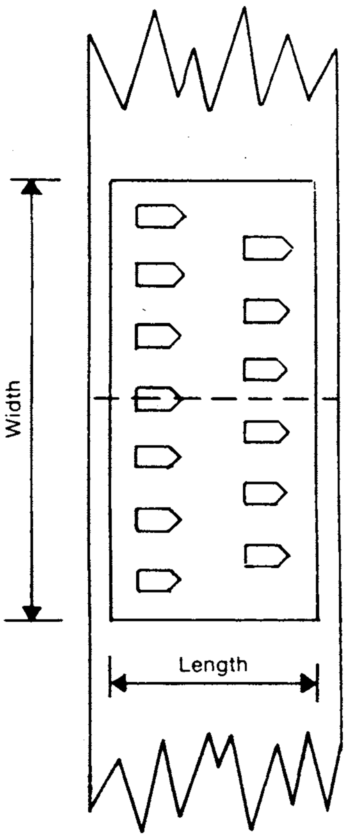

Figure E-2 - Truss Plate Length Perpendicular to Grain of Lumber.

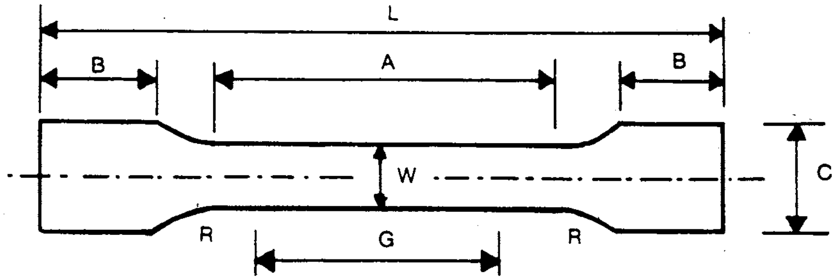

Figure E-3 - Solid Plate Specimen (for Dimensions, see Method E 8).

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APPENDIX F

EFFECTIVE SHEAR RESISTANCE FOR TRUSS PLATES[1]

F.1 General

F.1.1 The use of steel truss plates to fasten wood members together is a widely accepted practice. In many applications, the truss plates must resist shear forces.

F.1.2 Plates must resist shear in two planes. First, they must resist the force created by the wood member at the interface of plates and wood members. The plate's resistance of a shear force in this plane is a measure of the ability of the teeth, nails, plugs, etc. to transmit forces from the wood member to the plate. This shear force is developed as the unit plate value in pounds per square inch of plate, or pounds per nail, tooth or plug. The method for arriving at the unit plate design value is described in ASTM D 1761.

F.1.3 Secondly, a plate must resist shear through its cross-section in a plane perpendicular to the face of the plate. This resistance to shear is a measure of the ability of the plate to transmit forces within the plate itself. This test method is to be used for determination of unit design values for pairs of steel truss plates (one on each side of the connection) subject to a shear force through their cross-section.

F.1.4 During manufacture and subsequent loading of the truss plates, stress concentrations develop around holes, teeth, nails, plugs, etc. Because of these stress concentrations and the difficulty of predicting the path of failure, design values for truss plates should be based on tests rather than analytical methods. The shear resistance of the perforated plate is compared to the theoretical shear resistance of a solid control plate to arrive at the effective shear resistance ratio of the perforated plate.

F.1.5 If a given section taken through the length of a truss plate differs in geometric character from a section taken in an alternate orientation, the effective shear resistance ratio of the plate will be a function of this orientation. If this is the case, the method presented here requires that the net section of the plate must be evaluated at six different orientations.

F.1.6 If the net cross-section of plate is identical for all orientations, only one test along its length shall be necessary. The resulting effective shear resistance ratio of the plate is then applicable to all orientations of the plate.

F.1.7 If the effective shear resistance ratio is desired for any specific angle of plate orientation, it may be evaluated by this method.

F.1.8 If the plate is without holes immediately prior to truss fabrication, and nails and holes are never located along the shear plane, tests on specimens made using the manufacturer's recommended minimum edge spacing shall be used to determine the effective shear resistance ratio by this method.

F.1.9 Since shear tests are difficult to perform on the control plates, tensile tests of the control plates are substituted. Such tests are conducted in accordance with ASTM E 8. Tensile values are related to shear values by the accepted Von Mises yield theory which indicates that yielding in shear occurs at a stress equal to 0.577 of the yield stress in tension (AISI, Part V, p. 13 & 14). It is assumed that the ultimate shear stress and ultimate tensile stress are in the same ratio.

F.2 Definitions (For purpose of this test method only.)

A	Cross-section area of solid steel specimen.
A_p	Cross-section area of perforated specimen.
a	Angle of placement for plates tested at a specific orientation. (See 108.3 and Figure F-1 to F-3 incl.)
F_s	Theoretical ultimate shear stress of the solid control plate ($0.577F_t$).
F_t	Ultimate tensile stress of base metal solid control plate.
F_v	Basic allowable shear stress in steel.
f_s	Ultimate shear stress of the perforated plate.
L	Gross length of perforated plate.

[1] This method is under the jurisdiction of the ASTM Committee E-6 on Performance of Building Constructions, and is the direct responsibility of subcommittee E06.13 on structural performance of joining and fastening in building constructions. Current edition approved Oct. 31, 1980 published August 1981.

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ℓ	Calculated shear length of plate orientated at an angle (a) to the joint.
P	Ultimate shear force carried by control plate.
R_s	Effective shear resistance ratio, f_s/F_s.
T	Ultimate tensile force carried by the control plate.
t	Gross thickness of perforated plate and of solid control plate.
t_1	Base metal thickness of perforated plate and of solid control plate after deducting coating thickness, divided by 0.95.
V	Allowable plate shear design value for a single plate.
W	Gross width of perforated plate.

F.3 Scope

F.3.1 This method provides a basic procedure for evaluating the effective shear resistance of the net section of steel truss plates.

F.3.2 The test also provides a basis for determining the comparative performance of different types of steel truss plates resisting shear forces.

F.4 Applicable Documents

F.4.1 ASTM Standards

A 446 *Standard Specification for Steel Sheet, Zinc Coated (Galvanized) by the Hot-Dip Process, Physical (Structural) Quality*

A 525 *Standard Specification for Steel Sheet, Zinc Coated (Galvanized) by the Hot-Dip Process, General Requirements*

A 591 *Standard Specification for Steel Sheet, Cold Rolled, Electrolytic Zinc Coated*

A 792 *Standard Specification for General Requirements for Steel Sheet, Aluminum-Zinc Alloy Coated by the Hot Dip Process*

A 167 *Standard Specification for Stainless and Heat-Resistant Chromium-Nickel Steel Plate, Sheet and Strip*

D 1761 *Standard Methods of Testing Mechanical Fasteners in Wood*

E 4 *Standard Methods of Verification of Testing Machines*

E 8 *Standard Methods of Tension Testing of Metallic Materials*

E 489 *Standard Test Method for Tensile Strength Properties of Steel Truss Plates*

F.4.2 American Iron and Steel Institute *Specification for the Design of Cold-Formed Steel Structural Members*

F.5 Summary of Method

This method provides procedures for shear tests of manufactured steel truss plates, tension tests of control plates of the same material used in the manufacture of the truss plates, and a comparison of the truss plates with the control plates in terms of effectiveness. By multiplying the effective shear resistance ratio (for applicable orientation) by the basic allowable shear stress for the plate steel times the gross cross-sectional area of the truss plate (for applicable orientation) the maximum design load for a single truss plate in shear is determined; i.e.,

$$\text{Maximum design load} = R_s F_v \ell t_1$$

F.6 Significance

The resistance of a steel truss plate to shear forces is one measure of its ability to transmit loads from wood member to wood member where the forces must be transferred through the truss plate. Factors affecting the performance of the truss plate, neglecting the effects of the truss plate protrusions and of the lumber are: length, width, and thickness of the truss plate; location, spacing, orientation, size, and shape of holes in the truss plate; edge distance of holes in the truss plate; stress concentrations around projections and perforations of the truss plate; basic properties of the plate steel.

F.7 Apparatus

F.7.1 Testing Machine—Any suitable testing machine capable of imposing tensile and compressive forces to an accuracy of ± 1 percent when calibrated in accordance with ASTM Method E 4.

F.7.2 Grips—Any self-centering gripping devices designed to hold the solid control specimen, to allow accurate specimen positioning, and to provide complete rotational freedom are suitable. The grips should be designed so as to allow uniform axial tensile loading of the control plate across its total cross-sectional area.

F.7.3 Surfaces—The testing machine shall have parallel surfaces. The surfaces and placement of the assembly should allow uniform axial loading of the specimen.

F.8 Test Material

F.8.1 Truss Plates—The truss plates shall be typical of production, manufactured in

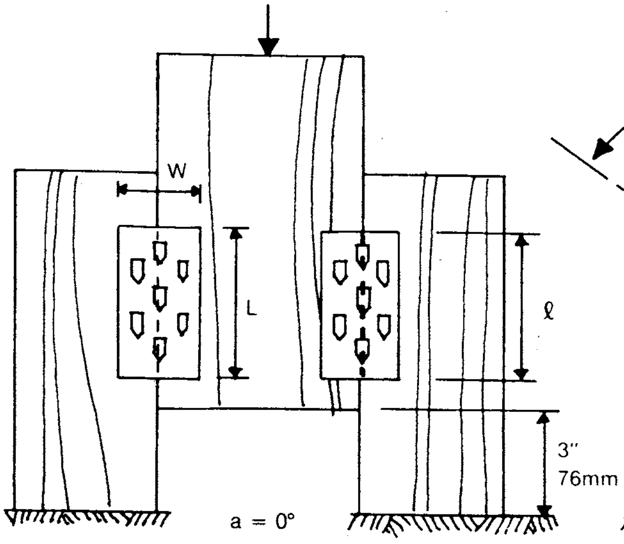


Figure F-1 - Zero Degree Orientation

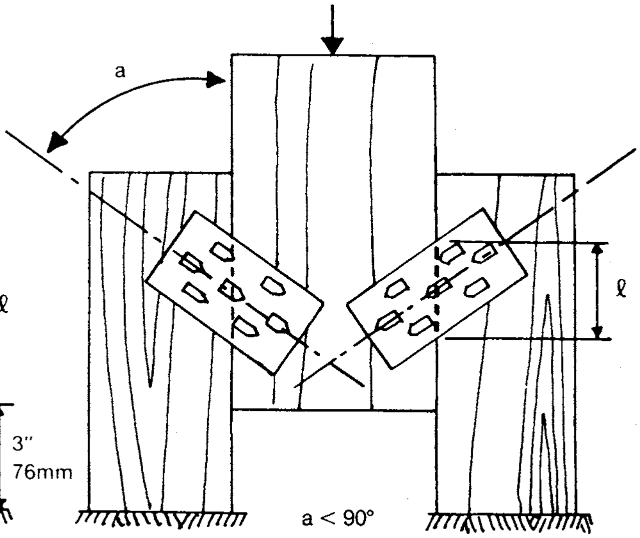


Figure F-2 - Acute Angle Orientation

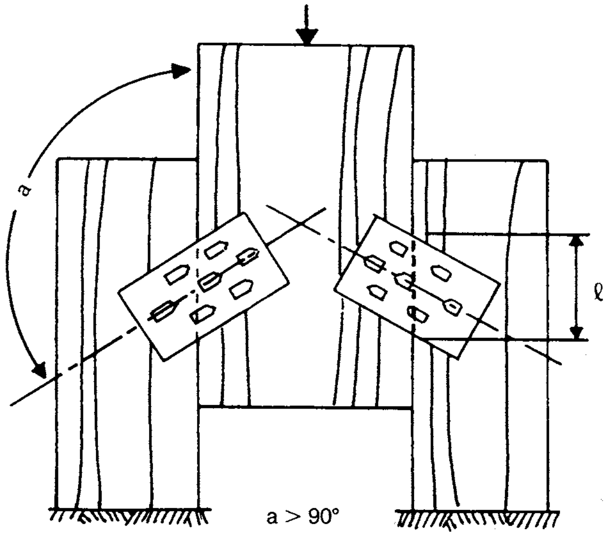


Figure F-3 - Obtuse Angle Orientation

NOTE: In Figures F-1, F-2, and F-3, outside members of test specimen must be maintained in a parallel and vertical orientation by suitable means of restraint.

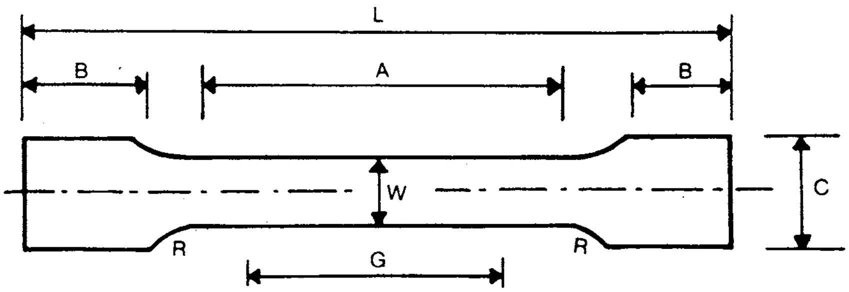


Figure F-4 - Control Specimen

accordance with design, and of materials specified by the manufacturer.

F.8.2 Control Plates—The material for control plates shall be from an adjacent area of the same slit coil and of the same finish as the manufactured truss plate.

F.9 Sampling

F.9.1 Sampling shall provide for selection, on an objective and unbiased basis, of representative test specimens made of material taken from several batches of steel. Truss plate samples shall be from typical production and take into account the different widths and thicknesses of plates produced for each thickness and for each configuration of plate to be tested.

F.9.2 For tests at six specific plate orientations: twelve truss plates consisting of three identical assemblies of four plates each. Assemblies are defined in F.10.1. At required orientations, angle "a" will measure 0°, 30°, 60°, 90°, 120°, and 150°, and is defined in F.9.3.

F.9.3 Angle of Inclination—Angle "a" is angle of inclination between wood joint in test sample (placed vertical) and length of truss plate. A zero degree angle is defined when length of the truss plate is parallel to wood joint. See Figure F-1. Values for "a" greater than zero are described when length of plate is rotated counterclockwise from vertical (zero) position. See Figures F-2 & F-3.

F.9.4 For Control Plates—Three solid plates shall be selected from the same slit coil utilized to make the perforated plates in F.9.2.

F.10 Test Specimen

F.10.1 Truss Plates—Truss plates chosen for evaluation of their net section at six orientations shall be firmly embedded, without removal of any teeth, in an assembly containing four equal size plates, one on each side of each joint interface with the length of plate inclined at angle "a" to wood joint and with the minimum net section of the plate directly over the joint. Care shall be taken to avoid over-pressing the plates. Teeth, nails, plugs shall be completely embedded, but the plate thickness shall not be forced below the surface of the wood. Such embedment procedure is to be consistent with the method of embedding the plates in the fabrication process, i.e., by pressing or rolling. The three wood members shall be placed so that the joint and lumber grain are in the same direction. The ends of the center member shall be 3 inches minimum above the corresponding ends of the outer members (Figure F-1). The joints in the assembly shall be a close fit but not compressed. Lumber edges shall not be modified from the dressed surface condition. In all cases, the plates should be sufficiently long to induce failure in the plate metal, rather than failure by tooth, prong or barb withdrawal. Alternatively, the plates may be clamped or otherwise firmly fastened a minimum of 2 inches from the joint to prevent withdrawal.

F.10.2 Control Specimen—The control specimens shall be prepared in accordance with ASTM E8 (Figure F-4). Deduct coating thickness (as described in ASTM A 446 for type of coating used) so that all calculations are made using base metal thickness.

F.10.3 Coating Thickness—Unless otherwise specifically defined for the type of coating used, see Sect 2.2.6.

F.11 Procedure

F.11.1 General—Measure all plates before testing to determine their gross width (W) and length (L) to nearest 0.01 inch, and thickness (t) to the nearest 0.001 inch. Take measurements at least at three different locations on each plate, using the average of three readings for record. For plates to be tested at any orientation, the angle (a) shall be accurately measured for use in calculating the length of plate (ℓ) along the shear line. When angle of placement equals 0° and 90°, ℓ equals L and W, respectively. (See Figures F-1, F-2, and F-3.) Deduct coating thickness (as described in ASTM A 446 for type of coating used) so that all calculations are made using base metal thickness (t_1).

F.11.2 Testing Control Plates—Conduct tests on control plates in accordance with ASTM E 8. Care must be taken to insure a uniform stress distribution and to prevent premature failure of the specimen in the grips of the testing machine. Where required, use special grips. Apply the load throughout the test at a uniform rate of separation of the platens of the testing machine so that the maximum load is reached in not less than 60 seconds.

F.11.3 Testing Truss Plate Assemblies—Conduct the truss plate assembly tests by placing the specimen assembly between and perpendicular to the testing machine platens. Apply the load throughout the test at a uniform rate so that the maximum load is reached in not less than 60 seconds.

F.11.4 Data Required—For the perforated specimens and control specimens, observe the yield-point loads, if obtainable, and ultimate loads in pounds-force with an accuracy corresponding to the smallest graduation on the load scale of the testing machine used.

F.12 Calculations

F.12.1 Calculate the ultimate tensile strength (F_t) of the solid section specimen by dividing the ultimate load in tension (T) by the base metal cross-sectional area (A), i.e., $F_t = T/A$. The average of three tests shall be used in further calculations.

F.12.2 Determine the theoretical ultimate shear stress of the solid section (F_s) by multiplying the average ultimate tensile stress (F_t) by 0.577, i.e., $F_s = 0.577F_t$.

F.12.3 Calculate the perforated plate ultimate shear stress (f_s) by dividing one-fourth of the ultimate load (P) by the base metal gross cross-sectional area of each perforated plate specimen. The base metal gross cross-sectional area is obtained by multiplying ℓ by t_1. The average of three tests shall be used in further calculations.

F.12.4 Calculate the average effective shear resistance ratio (R_s) by dividing the average perforated plate ultimate shear stress (f_s) by the theoretical ultimate shear stress of the solid section (F_s), i.e.,

$$R_s = \frac{f_s}{F_s} = \frac{f_s}{0.577F_t}$$

F.12.5 Determine the average effective shear resistance ratio (R_s) for each orientation of the plate.

F.12.6 Allowable design values in shear (pounds per lineal inch) may be determined for individual truss plates by multiplying the basic allowable shear stress for the grade of steel used (F_v) by the appropriate effective shear resistance ratio (R_s) and the base metal thickness (t_1) of the truss plate for the plate orientation desired, i.e.,

$$V_s = (R_sF_vt_1)2$$

This value is for a pair of plates, one on each face of the joint.

F.13 Report

The report shall include the following information:

(a) Date of test and date of report.

(b) Test sponsor and test agency.

(c) Identification of test specimens: Manufacturer, model type, material, finish, shape, dimensions, and other pertinent information such as cracks and other defects. Material specifications shall include basic allowable tensile stress and basic allowable shear stress.

(d) Detailed drawings or photographs of test specimens before and after testing if not fully described otherwise.

(e) Complete description of test method and loading procedures used if there are any deviations from the prescribed or recommended methods as outlined in this standard.

(f) Number of specimens tested.

(g) All test data, including maxima, minima, and averages.

(h) Effective shear resistance ratio for each individual test specimen and averages for all identical test specimens.

(i) Description of type and path of failure.

(j) Summary of findings.

(k) Listing of observers and signatures of responsible persons.

F.14 Precision & Accuracy

Neither the within-laboratory nor the between-laboratory precision and accuracy of this method has been established.

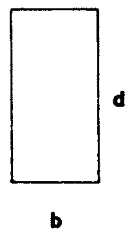
APPENDIX G

REFERENCES

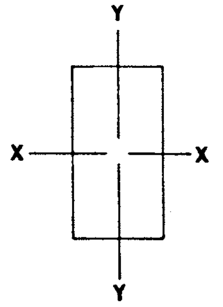
1. *National Design Specification for Wood Construction*, 1982 Edition, recommended practice by the National Forest Products Association
2. *Specification for the Design of Cold-Formed Steel Structural Members*, 1980 Edition, American Iron and Steel Institute
3. *Digital Computer Program for Analysis of Member Stresses in Symmetric W Trusses*, Research Bulletin No. 783, August 1964, Wood Research Laboratory, Purdue University, Agricultural Experiment Station, Lafayette, Indiana 47907
4. *Report to the Design Subcommittee of the Joint Industry Advisory Committee on Roof Trusses*, June 25, 1964
5. *Contact Area Stresses and Buckling Resistance of Light Gauge Metal Heel Plates for Wood Trusses*, Paper No. 70-410, American Society of Agricultural Engineers, 2950 Niles Road, St. Joseph, Michigan 49085
6. ASTM A 446-83, *Standard Specification for Steel Sheet, Zinc Coated (Galvanized) by the Hot-Dip Process, Physical (Structural) Quality*
7. ASTM D 245-81, *Standard Methods for Establishing Structural Grades and Related Allowable Properties for Visually Graded Lumber*
8. ASTM D 1761-77, *Standard Methods of Testing Mechanical Fasteners in Wood*
9. ASTM E 489-81, *Standard Method of Test for Tensile Strength Properties of Steel Truss Plates*
10. ASTM E 67-80, *Standard Test Method For Shear Resistance of Steel Truss Plates.*
11. *Quality Control Manual*, published by the Truss Plate Institute, Inc.
12. *Bracing Wood Trusses: Commentary and Recommendations*, published by the Truss Plate Institute, Inc.
13. *Standard Grading Rules (No. 16) for West Coast Lumber*, September 1, 1970 (revised 1984), West Coast Lumber Inspection Bureau (WCLIB)
14. *1977 Grading Rules*, Southern Pine Inspection Bureau (SPIB)
15. *1984 Standard Grading Rules for Western Lumber*, Western Wood Products Association (WWPA)
16. *Standard Grading Rules for Northeastern Lumber*, 1980, Northeastern Lumber Manufacturers Association, Inc. (NELMA)
17. *Official Grading Rules, Dec. 1978 (with supplements)*, Northern Hardwood and Pine Manufacturers Association Inc. (NHPMA)
18. *1970 Standard Grading Rules for Canadian Lumber (US Edition)*, including supplements to Nov. 1984 National Lumber Grades Authority (NLGA)
19. *American Softwood Lumber Standard, Voluntary Product Standard PS 20-70*, published by the National Bureau of Standards, U.S. Department of Commerce
20. *A Computerized Wood Engineering System: Purdue Plane Structures Analyzer*, USDA Forest Service Research Paper FPL 168, published by the Forest Products Laboratory
21. *Structural Lumber—Fire-Retardant Treatment by Pressure Processes* (C20), American Wood Preservers Association
22. Truss Plate Institute, Interim Guidelines

APPENDIX H

STANDARD LUMBER AND TIMBER SIZES AND PROPERTIES OF SECTIONS



PROPERTIES OF SECTIONS



Nominal Size Inches b d	Actual Size Inches b d	Area In.^{2}	AXIS XX S In.^{3}	AXIS XX I In.^{4}	AXIS YY S In.^{3}	AXIS YY I In.^{4}	Board Measure per Lineal Foot	Weight per Lineal Foot Lbs.
2 x 2	1-1/2 x 1-1/2	2.25	.56	.42	.56	.42	.33	.63
3	2-1/2	3.75	1.56	1.95	.94	.70	.50	1.05
4	3-1/2	5.25	3.06	5.36	1.31	.99	.67	1.46
2 x 5	1-1/2 x 4-1/2	6.75	5.06	11.39	1.69	1.27	.83	1.87
6	5-1/2	8.25	7.56	20.80	2.06	1.55	1.00	2.29
8	7-1/4	10.88	13.14	47.63	2.72	2.06	1.33	2.98
10	9-1/4	13.88	21.39	98.93	3.57	2.62	1.67	3.87
12	11-1/4	16.88	31.64	177.98	4.23	3.18	2.00	4.68
14	13-1/4	19.88	43.89	290.77	4.97	3.75	2.33	5.50
3 x 3	2-1/2 x 2-1/2	6.25	2.61	3.25	2.6	3.24	.75	1.73
4	3-1/2	8.75	5.10	8.93	3.64	4.56	1.00	2.43
6	5-1/2	13.75	12.60	34.66	5.73	7.16	1.50	3.82
8	7-1/4	18.13	21.90	79.39	7.56	9.53	2.00	5.03
10	9-1/4	23.13	35.65	164.88	9.63	12.16	2.50	6.44
12	11-1/4	28.13	52.73	296.63	11.75	14.79	3.00	7.83
14	13-1/4	33.13	73.15	484.63	14.91	17.34	3.50	9.18
4 x 4	3-1/2 x 3-1/2	12.25	7.15	12.50	7.14	12.52	1.33	3.39
6	5-1/2	19.25	17.65	48.53	11.23	19.64	2.00	5.34
8	7-1/4	25.38	30.66	111.15	14.82	26.15	2.67	7.05
10	9-1/4	32.38	49.91	230.84	18.97	33.23	3.33	8.98
12	11-1/4	39.38	73.82	415.28	23.03	40.30	4.00	10.91
14	13-1/4	46.38	102.41	678.48	27.07	47.59	4.67	12.90
★6 x 6	5-1/2 x 5-1/2	30.25	27.73	76.25	27.73	76.25	3	8.40
8	7-1/2	41.25	51.56	193.35	37.81	103.98	4	11.46
10	9-1/2	52.25	82.73	392.96	47.89	131.71	5	14.51
12	11-1/2	63.25	121.23	697.07	57.98	159.44	6	17.57
14	13-1/2	74.25	167.06	1127.67	68.06	187.17	7	20.62
★8 x 8	7-1/2 x 7-1/2	56.25	70.31	263.67	70.31	263.67	5.33	15.62
10	9-1/2	71.25	112.81	535.86	89.06	333.98	6.67	19.79
12	11-1/2	86.25	165.31	950.55	107.81	404.30	8	23.96
14	13-1/2	101.25	227.81	1537.73	126.56	474.61	9.33	28.12
★10 x 10	9-1/2 x 9-1/2	90.25	142.89	678.75	142.89	678.75	8.33	25.07
12	11-1/2	109.25	209.39	1204.03	172.98	821.65	10	30.35
14	13-1/2	128.25	288.56	1947.80	203.06	964.25	11.67	35.62
★12 x 12	11-1/2 x 11-1/2	132.25	253.48	1457.51	253.48	1457.51	12	36.74
14	13-1/2	155.25	349.31	2357.86	297.56	1710.98	14	43.12
★14 x 14	13-1/2 x 13-1/2	182.25	410.06	2767.92	410.06	2767.92	16.33	50.62

★ *Note: Properties are based on minimum actual dressed green size*

APPENDIX I

DESIGN VALUE ADJUSTMENTS FOR DURATION OF LOAD

See: Figure I-1 below; *Commentary on Load Duration Effects for Wood*, Truss Plate Institute; and Appendix B, NDS.

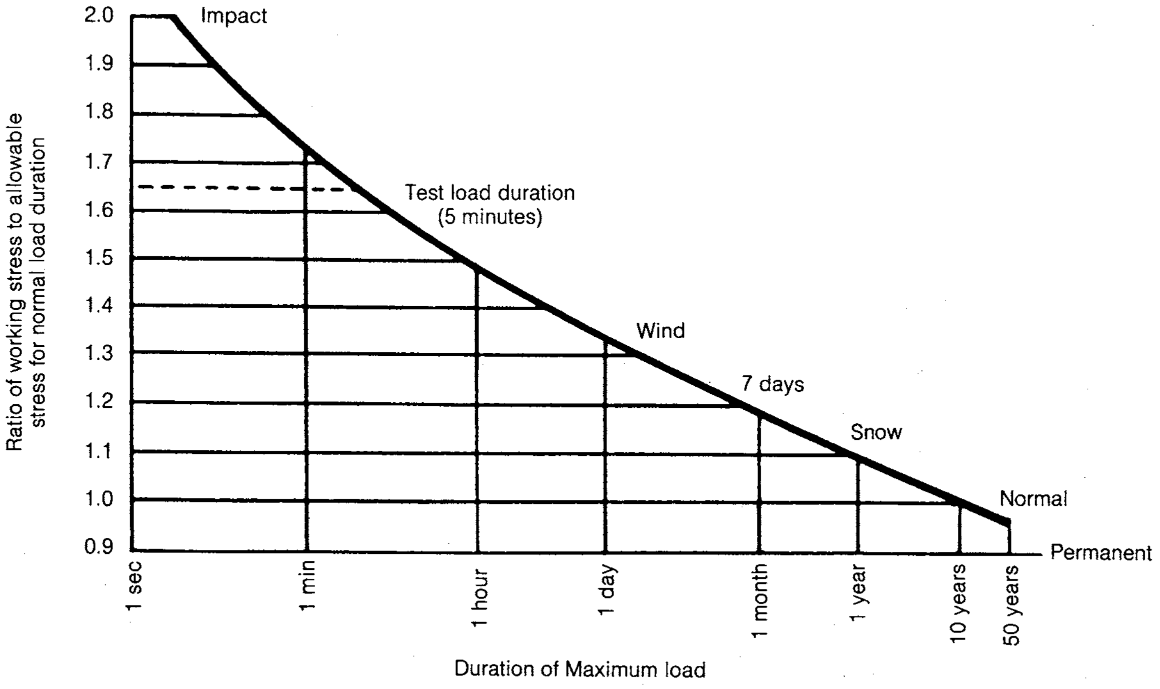


Figure I-1 Derived from Forest Products Laboratory Report No. R1916.

APPENDIX J

WEIGHTS OF CONSTRUCTION MATERIALS

The average figures and ranges given in this table are suitable for general use. Specific products may vary considerably from these values; therefore, where available, actual weights as given in manufacturer's catalogs and in various reference books should be used.

Material	Weight, psf
Ceilings	
Acoustical Fiber tile	1.0
Channel suspended system	1.0
Plaster and lath (see *Walls and Partitions)*	
Floors	
Hardwood, 1 in. nominal	4.0
[1]Plywood: 15/32 and ½ in.	1.5
19/32 and ⅝ in.	1.8
29/32 and ¾ in.	2.2
[1]Oriented Strand Board and Waferboard: 7/16 in.	1.5
½ in.	1.7
¾ in.	2.5
Asphalt mastic, per inch of thickness	12.0
Cement finish, per inch of thickness	12.0
Ceramic or quarry tile, ¾ in.	10.0
Concrete, per inch of thickness	
Lightweight	6.0 to 10.0
Reinforced	12.5
Stone	12.0
Cork tile, 1/16 in.	0.5
Flexicore, 6 in. slab	46.0
Linoleum, ¼ in.	1.0
Terrazo finish, 1½ in.	19.0
Vinyl tile, ⅛ in.	1.4
Roofs	
Lumber sheathing, in. nominal	2.5
[1]Plywood sheathing:	
15/32 and ½ in.	1.5
19/32 and ⅝ in.	1.8
[1]Oriented Strand Board and Waferboard: 7/16 in.	1.5
½ in.	1.7

Timber decking 15% MC	2 in. nom.	3 in. nom.	4 in. nom.
Cedar, Alaska, incense, and Port Orford	3.5	5.5	7.5
Cedar, Western red	3.0	6.0	6.7
Douglas fir	4.3	7.0	9.3
Fir, white	3.7	6.0	8.0
Hemlock, West coast	4.0	6.5	8.7
Larch	5.0	8.0	10.5
Pine, Idaho white and ponderosa	4.0	6.3	8.3
Pine, lodgepole	4.0	6.5	8.5
Pine, Southern	5.0	8.0	10.5
Pine, sugar	3.5	5.7	7.5
Spruce, Engelmann	3.0	5.0	6.7
Spruce, Sitka	3.8	6.0	8.2
Spruce, white	4.0	6.3	8.3

Aluminum (includes laps)	Flat	Corrug. (1½ and 2½ in.)
12 American or B & S ga	1.2	
14 or B & S ga	0.9	1.1
16 or B & S ga	0.7	0.9
18 or B & S ga	0.6	0.7
20 or B & S ga	0.5	0.6

Galvanized Steel (includes laps)	Flat	Corrug. (2½ and 3 in.)
12 U.S. Std. ga	4.5	4.9
14 U.S. Std. ga	3.3	3.6
16 U.S. Std. ga	2.7	2.9
18 U.S. Std. ga	2.2	2.4
20 U.S. Std. ga	1.7	2.8
22 U.S. Std. ga	1.4	1.5
24 U.S. Std. ga	1.2	1.3
26 U.S. Std. ga	0.9	1.0

Other decking, per inch of thickness	
Concrete plank	6.5
Insulrock	2.7
Petrical	2.7
Porex	2.7
Poured gypsum	6.5
Tectum	2.0

Data reproduced by courtesy of AISC, Inc.

[1] *Data reproduced by courtesy of American Plywood Association.*

Material	Weight, psf
Vermiculite concrete	2.6
Asbestos, corrugated, ¼ in.	3.0
Felt, 3 ply	1.5
Felt, 3 ply with gravel	5.5
Felt, 5 ply	2.5
Felt, 5 ply with gravel	6.5
Insulation, per inch of thickness	
Expanded polystyrene	0.2
Fiberglas, rigid	1.5
Loose	0.5
Roll roofing	1.0
Shingles	
Asphalt, approx, ¼in.	2.0
Book tile, 2 in.	12.0
Book tile, 3 in.	20.0
Cement asbestos, approx. ⅜ in.	4.0
Clay tile (for mortar add 10 lb)	9.0 to 14.0
Ludowici	10.0
Roman	12.0
Slate, ¼in.	10.0
Spanish	19.0
Wood, 1 in.	3.0
Walls and Partitions	
Wood paneling, 1 in.	2.5
Wood studes, 2 × 4	
12 in. o.c.	2.1
16 in. o.c.	1.7
24 in. o.c.	1.3
Glass block, 4 in.	18.0
Glass plate, ¼ in.	3.3
Glazed tile	18.0
Marble or marble wainscoting	15.0
Masonry, per 4 inches of thickness	
Brick	38.0
Concrete block	30.0
Cinder concrete block	20.0
Hollow clay tile, load-bearing	23.0
Hollow clay tile, nonbearing	18.0
Hollow gypsum block	13.0
Limestone	55.0
Terra-cotta tile	25.0
Stone	55.0
Plaster, 1 in.	8.0
Plaster, 1 in., on wood lath	10.0
Plaster, 1 in., on metal lath	8.5
Porcelain-enameled steel	3.0
Stucco, ⅞ in.	10.0
Windows, glass, frame and sash	8.0

Data reproduced by courtesy of AISC, Inc.

APPENDIX K

CONNECTOR PLATE EVALUATION SUMMARY SHEET

Test Lab ______________ Lab Report No. ______________

Compiled by ______________ Date ______________

PLATE

Designation ______________

Size ______________

Gage ______________

Thickness ______________

Coating ______________

Yield ______________

Ultimate ______________

Rockwell Hardness ______________

Effective Sq. In. ______________

Coupon No. ______________

TEST METHOD

Gross Area ______________

Net Area ______________

Orientation 0° ______________

Orientation 90° ______________

Other ______________

Method of Imbedment ______________

Date of Imbedment ______________

Date of Test ______________

WOOD

Species ______________

NDS Group (8.1A) ______________

NDS Specific Gravity ______________

Av. Specific Gravity ______________

$\frac{\text{Av. Sp. Gr.}}{\text{NDS. Sp. Gr.}} =$ ______________

			ULTIMATE			**0.30^{in} SLIP (WOOD TO WOOD)**			
Specimen Number	**Percent Moisture**	**Specific Gravity**	**Joint Load (lb.)**	**Pounds Per Tooth**	**lb/Tooth** **3.0**	**Joint Load (lb.)**	**Pounds Per Tooth**	**lb/Tooth** **1.6**	**METHOD OF FAILURE**
Avg. Sp. Gr.									AVG. TOOTH VALUE (lb/Tooth)

Design Value: ______________ lb/tooth: ______________ lb/in.^{2}

APPENDIX L

CONNECTOR PLATE EVALUATION DATA RECORD

PLATE: *Designation* ____________ *Size* ____________

Thickness ____________ *Method of Imbedment* ____________

Coupon No. ______ *Gross* ______ *Net* ______ *Effective Teeth* ______

Coating: ____________ WOOD: *Species* ______ *Group* ______

Moisture Content ____________ *Specific Gravity* ____________

Plate Orientation *0°* ____________ *90°* ____________ *Other* ____________

SPECIMEN NO. ____________

PAGE ______ OF ______

DATE ______ BY ______

TIME: END ____________

START ____________

ELAPSED____________

LOAD (POUNDS)	GAUGE READING (IN)			LOAD (POUNDS)	GAUGE READING (IN)		
	1	2	AVE.		1	2	AVE.
0				8000			
400				8400			
800				8800			
1200				9200			
1600				9600			
2000				10,000			
2400				10,400			
2800				10,800			
3200				11,200			
3600				11,600			
4000				12,000			
4400				12,400			
4800				12,800			
5200				13,200			
5600				13,600			
6000				14,000			
6400				14,400			
6800				14,800			
7200				15,200			
7600				15,600			

REMARKS

APPENDIX M

ADDITIONAL PUBLICATIONS AVAILABLE FROM TPI

BWT-76	*Bracing Wood Trusses:* Commentary and Recommendations
CSP-78	Recommended *Code of Standard Practice* for the Metal Plate Connected Wood Truss Industry
HET-80	Commentary and Recommendations for *Handling and Erecting Wood Trusses*
PCT-80	Design Specifications for Metal Plate Connected *Parallel Chord Wood Trusses*
QCM-77	*Quality Control Manual*
TPI-78	Design Specifications for Metal *Plate Connected Wood Trusses Interim Guidelines* (included)
FIRE TEST REPORT	Underwriters Laboratories one hour fire test on parallel chord truss protected with a single layer of ⅝″ type C wallboard, and Factory Mutual Research, one hour fire test on parallel chord truss protected with a double layer of ½″ type FSW-1 wallboard.